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WILDLIFE HABITAT EVALUATION OF THE UNCHANNELIZED  
MISSOURI RIVER IN SOUTH DAKOTA

BY  
JAMES R. CLAPP

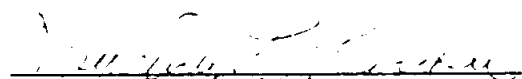
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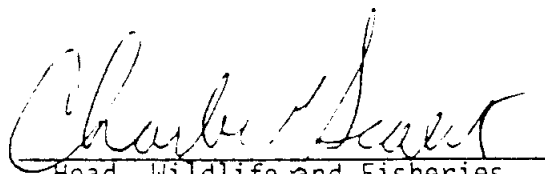
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This thesis is approved as a creditable and independent investigation by a candidate for the degree, Master of Science, and is acceptable for meeting the thesis requirements for this degree. Acceptance of this thesis does not imply that the conclusions reached by the candidate are necessarily the conclusions of the major department.

  
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WILDLIFE HABITAT EVALUATION OF THE UNCHANNELIZED  
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Abstract

JAMES R. CLAPP

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Areas of eight habitats were identified, delineated, and measured along the unchannelized Missouri River in South Dakota. Agricultural and urban developments existed on 60 percent of the land within 1 km of the river. Six habitat types made up the non-developed land in the study area: cottonwood-dogwood (16 percent), cottonwood-willow (9 percent), elm-oak (7 percent), cattail marsh (3 percent), sand dune (3 percent), and sand bar (1 percent). All non-developed habitats except sand bar were sampled to obtain vegetative composition and to determine their value to wildlife. The value of each habitat to nine faunal groups of wildlife was subjectively rated from 0 (poor) to 10 (excellent). An interspersation value was added to arrive at total habitat value.

Cattail marshes were typically monospecific stands of narrow-leaved cattail (Typha angustifolia) in slow-moving, shallow water. This habitat was rated highest in its value to wildlife (8.9), and was especially important for aquatic furbearers, waterfowl, other water and marsh birds, and herptiles.

Cottonwood-dogwood habitat generally consisted of three layers of vegetation: eastern cottonwood (Populus deltoides), red-osier

dogwood (Cornus stoloifera), and poison ivy (Toxicodendron rydbergii). A rating of 7.9 was given this habitat, and conditions were good for all terrestrial faunal groups except herptiles.

Cottonwood-willow stands were dominated by eastern cottonwood and various willows (Salix spp.) and occurred in a clumped distribution. Woody vegetation was interspersed with open areas covered with grasses, forbs, sedges (Carex spp.), or horsetail (Equisetum spp.), forming a system of edges. The total habitat value for cottonwood-willow communities was 7.5; big game and upland game birds found conditions excellent there.

Elm-oak habitat was comprised of a wide variety of trees; the most important were slippery elm (Ulmus rubra), bur oak (Quercus macrocarpa), box elder (Acer negundo), and eastern red cedar (Juniperus virginiana). Grazing of the understory and ground cover reduced the value of this habitat to most types of wildlife (6.7).

Sand dunes were deposited by floods occurring prior to the closure of Fort Randall Dam and Lewis and Clark Dam. Vegetation consisted of older cottonwoods probably existing prior to the floods and younger cottonwood/willow stands, interspersed with bare sand and patches of alfalfa. Conditions were fair for most species of wildlife (5.3), with terrestrial birds and herptiles receiving the most benefit.

Future alterations of the unchannelized river in the study area should be planned with an objective of leaving areas of all six habitats on non-developed land to maintain the diversity of wildlife presently found there.

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## INTRODUCTION

Water development programs of the U. S. Army Corps of Engineers and the U. S. Bureau of Reclamation have eliminated most of the free-flowing Missouri River. The Rivers and Harbors Act of 1945 authorized the construction of a permanent channel 9 ft (2.7 m) deep and 300 ft (91.4 m) wide from the mouth of the river to Sioux City, Iowa, to increase navigational safety and prevent streambank erosion. In 1961, the completion of the Kensler's Bend Project extended the stabilization structures 32 km upstream from Sioux City to Ponca State Park, Nebraska (U. S. Army Corps of Engineers 1960). The Flood Control Act of 1944 authorized full scale development of the remaining Missouri River Basin, with the U. S. Army Corps of Engineers building downstream reservoirs for navigation and flood control and the U. S. Bureau of Reclamation building upstream reservoirs for irrigation and other consumptive uses (Missouri River Basin Inter-agency Committee 1971). Three small sections of the Missouri River remain free-flowing: (1) 128 km between Garrison Dam, North Dakota, and the headwaters of Lake Oahe; (2) 66 km between Fort Randall Dam, South Dakota, and Running Water, South Dakota; and (3) 122 km between Gavins Point Dam and Sioux City, Iowa.

The effects of channelization on small streams and wetlands are documented (Barstow 1971, Bonnema 1972, Choate 1972, Bonnema and Zschomler 1974), but most large rivers were channelized or inundated by reservoirs prior to measurement of their value to wildlife. Funk

and Robinson (1974) used aerial photographs to determine differences in the area of wildlife habitat on the lower Missouri River before and after channelization. They found that populations of waterfowl and aquatic furbearers were greatly reduced when islands and the chutes and sloughs of backwater areas were eliminated. Clearing of bottomlands for agriculture and a reduction of habitat for forest-dwelling species also followed channelization.

This project was conducted to determine the value to wildlife of the free-flowing portion of the Missouri River between Nebraska and South Dakota. Specific objectives were:

- (1) to identify, delineate, and measure all habitats within 1 km of the free-flowing Missouri River between Fort Randall Dam, South Dakota, and Sioux City, Iowa;
- (2) to quantitatively describe understory and overstory of naturally vegetated habitats; and
- (3) to subjectively assign a habitat value to wildlife of each of the natural habitats.

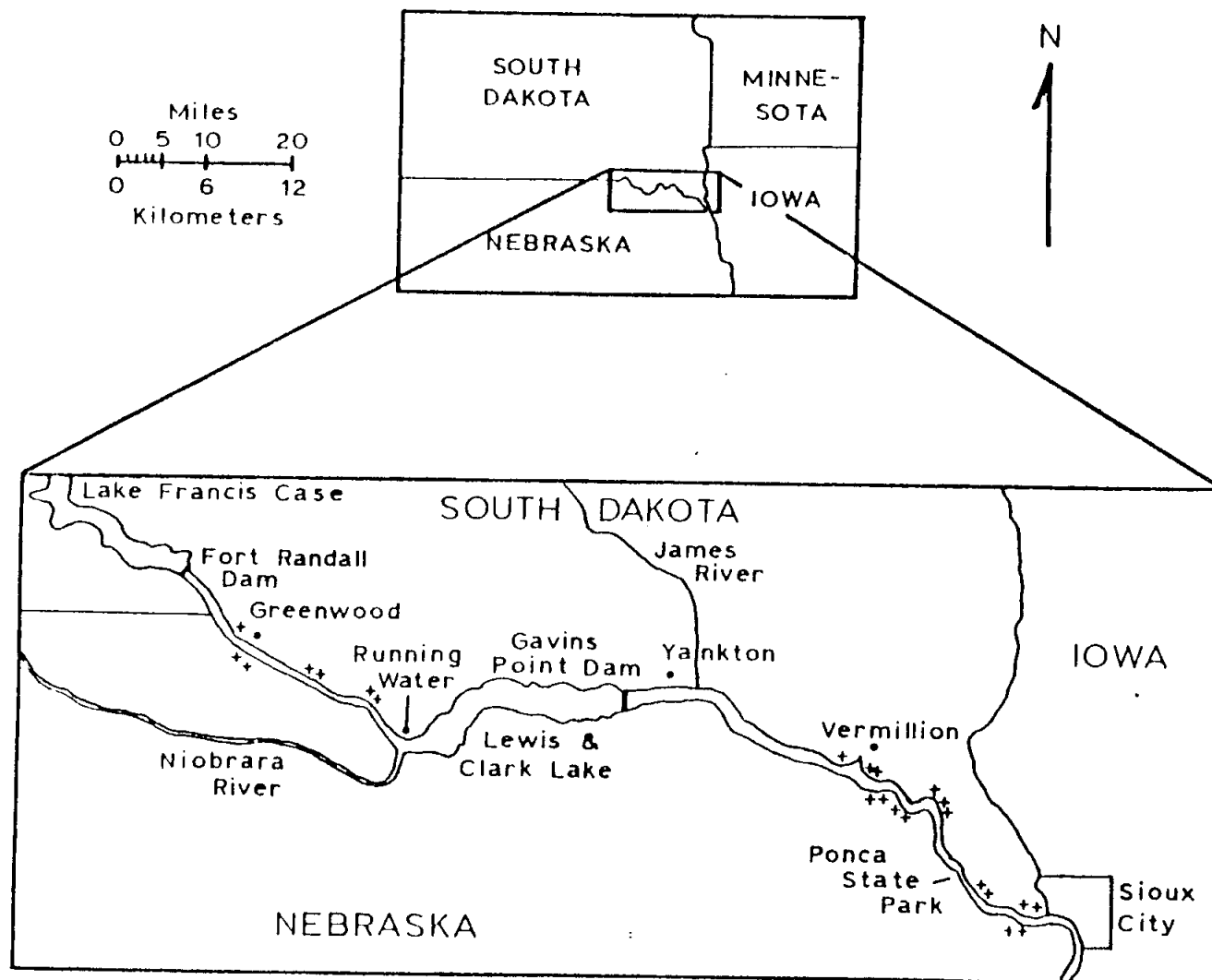


Figure 1. Locations of 23 sampling sites within the study area.

## STUDY AREA

### Description of the River

The study area consisted of riparian habitats along the Missouri River between Fort Randall Dam, South Dakota, and Sioux City, Iowa. This river section is approximately 190 km, and excludes Lewis and Clark Lake, a man-made reservoir behind Gavins Point Dam (Fig. 1).

Most of the river in the study area remains in natural condition. The river channel constantly changes location and velocity, resulting in frequent changes in river width (0.4 - 2.4 km) and depth (0 - 10 m). Variation in water flow causes frequent changes in the locations and sizes of sandbars. Numerous islands of various sizes and stages of vegetational complexity and stability are present.

The banks of the river from Ponca State Park to Sioux City have been stabilized with rock revetments and dikes. Stable sandbars occur behind the dikes, but shifting bars characteristic of the free-flowing river are absent. There are no islands in this portion of the river.

### Physiography

The study area was located in the Missouri River Trench division of the Central Lowlands (Flint 1955, cited by Westin et al. 1967). The river and a narrow alluvial floodplain dissect rolling to precipitous bluffs between Fort Randall Dam and Running Water. Steep and rolling bluffs are also on the Nebraska side of the Missouri River between

Gavins Point Dam and Sioux City. In some locations, a narrower floodplain occurs between the river and the bluffs; in others, the bluffs rise sharply from the edge of the river. The South Dakota side of the river between Gavins Point Dam and Sioux City has a wide, level floodplain. River elevations range from 440 m (Fort Randall Dam) to 340 m (Sioux City) above sea level.

#### Soils and Land Use

Bottomland soils are generally thin and include three Chernozem soils: (1) loamy sands, (2) loams (sandy, silt, silty clay, and clay), and (3) clays (Roberts et al. 1928, Goke and Brown 1929, Hayes et al. 1930, Moran et al. 1933, Westin et al. 1967, Slama et al. 1976). Soils of the bluffs are generally silt loams east of Gavins Point Dam, and clays or clay loams west. Major land use is agriculture, with bottomland suitable for corn, oats, soybeans, and alfalfa; bluffs are grazed by cattle.

#### Vegetation

Küchler (1964) classified the natural vegetation as the northern floodplain forest. Floodplain vegetation between Gavins Point Dam and Sioux City has been studied (Johnson 1949, Van Bruggen 1961, Heckel 1963, Wilson 1970, Lawrey 1973). Lawrey (1973) classified the riparian vegetation into five communities: cattail, cattail-willow-cottonwood, willow-cottonwood, cottonwood-dogwood, and elm-ash-mulberry. The common and scientific names of plants referred to in the text are



listed in Appendix A.

Narrow-leaved cattail, found wherever shallow water covers the soil surface, becomes stunted and dies when the soil becomes exposed (Weaver 1960). Dense stands of peach-leaved willow, sandbar willow, and eastern cottonwood become established on exposed barren substrates. As cottonwood trees increase in size, willows die from competition and lack of light (Vaubel and Hoffman 1975). When cottonwoods dominate the community, the shrub layer consists of red-osier dogwood, with Virginia creeper and poison ivy forming a dense ground cover. Lawrey (1973) felt that climax vegetation consisted of slippery elm, green ash, and mulberry, with an understory of red-osier dogwood and riverbank grape. Vaubel and Hoffman (1975) found elm-sycamore to be a transitional seral stage between the cottonwood stage and the probable climax stage, which consisted of bur oak, shagbark hickory, slippery elm, and basswood. Important shrubs in the transitional seral stage were red-osier dogwood, wolfberry, and gooseberry. Although Vaubel and Hoffman (1975) made their study of vegetation south of Sioux City, the climax community they described appears to be representative of vegetation found on the Nebraska bluffs.

#### Climate

The climate in the study area is continental, characterized by cold winters and hot summers (Spuhler and Lytle 1971). The average annual temperature is 8.9 C, and extreme temperatures of -29 C (low) and 38 C (high) are recorded at least once each year. Average annual

precipitation is 63 cm, of which approximately 77 percent falls during the growing season (1 April to 31 September). Snowfall averages 65 cm per year. Prevailing winds are generally 16 to 18 km per hour, and blow from the northwest during the winter and from the southeast during the summer.

## METHODS

Measurement of habitat values to wildlife was based on the concept that all land has a value to wildlife (Daniel and Lamaire 1974), and that this value can be subjectively rated from 0 (poor) to 10 (excellent). The procedures I used are outlined in the Habitat Evaluation Procedures manual (U. S. Fish and Wildlife Service 1976). Natural and agricultural/urban habitat types were delineated. Random sampling sites were used to gather data on overstory and understory composition in each natural habitat type and to determine the value of each type to various categories of wildlife.

### Delineation of Habitat Types

Areas of eight distinguishable habitat types within 1 km of both sides of the river were measured and identified by code on aerial photographs (scale = 1:24,000). Identification of each habitat type was verified by field observation.

### Sampling Sites

The study area was divided into three segments: (1) Fort Randall Dam to Running Water, (2) Gavins Point Dam to Ponca State Park, and (3) Ponca State Park to Sioux City. Twenty-three sites were selected for sampling during June through August 1976 (Table 1, Fig. 1).

Habitat evaluation was not conducted on sandbars or agricultural/urban land. Sandbar location, size, and total area change from year

Table 1. Number of sampling sites in each habitat type within the study area.

Habitat Type	Segment			Total
	1 <sup>a</sup>	2 <sup>b</sup>	3 <sup>c</sup>	
Sand dune	1	1	1	3
Cattail marsh	2	0	0	2
Cottonwood-willow	0	3	2	5
Cottonwood-dogwood	3	3	2	8
Elm-oak	1	3	1	5
Total	7	10	6	23

<sup>a</sup>Fort Randall Dam, South Dakota, to Running Water, South Dakota.

<sup>b</sup>Gavins Point Dam to Ponca State Park, Nebraska.

<sup>c</sup>Ponca State Park to Sioux City, Iowa.

to year with differences in the river channel flow.

Number of sampling sites in each segment was based on the percentage that each habitat type within the segment represented of the total natural habitat measured along the river. In this way, sampling sites were located in all segments. Sampling sites were selected from randomly chosen aerial photographs; specific site locations were based on accessibility. A 100 m square (1 ha) intensive sampling area was not randomly chosen but was selected to include vegetation representative of the habitat type on each sampling site.

#### Vegetation Sampling

Trees were sampled on two 10 m by 25 m (1/40 ha) plots in each sampling area following procedures described by Lawrey (1973) and Vaubel and Hoffman (1975). Peach-leaved willows and sandbar willows, which occurred as shrubs or trees, were recorded as shrubs when less than 1 cm diameter at breast height (DBH) and as trees when greater than 1 cm DBH. Relative dominance (basal area), density, and frequency of trees in each habitat type were calculated from this information. Values were summed for each species to yield an importance value, which could range from 0 to 300. All formulas used in vegetation analyses are presented in Appendix B.

Shrub composition was analyzed by a modification of the line intercept method of Bauer (1943). Two line transects were oriented the length of each plot used for tree analysis. The number of times

each species was intersected by these transects was recorded to measure relative density and frequency. Relative density and frequency for each shrub species in each habitat type were summed to derive a shrub importance value, which could range from 0 to 200. Species of arboreal and ground covering vines in each sampling site were recorded to measure frequency of each species.

An overlap, or similarity, index was used to compare the overstory and understory vegetation of each sampling site containing woody vegetation to that of each of the other sites. The formula, developed by Horn (1966), and its application are described in Appendix C. Cluster analysis was used to place each of the sampling sites into similar groupings (habitat types) based on their similarity values. Calculations were performed by computer with an unweighted pair-group method using arithmetic averages as described by Sneath and Sokal (1973). The vegetational relationships between sites as depicted by cluster analysis were shown as a phenogram.

#### Habitat Type Evaluation

To obtain a base value, each habitat type was rated according to its value to each of nine faunal groupings of wildlife: (1) big game, (2) upland game mammals, (3) furbearers, (4) small mammals, (5) upland game birds, (6) waterfowl, (7) other water and marsh birds, (8) terrestrial birds, and (9) reptiles and amphibians (herptiles). Ratings were based upon such characteristics as plant density, understory, relative abundance of plants valuable to wildlife, and

degree of grazing as suggested by Daniel and Lamaire (1974). I also took into consideration the degree to which the area was used by wildlife as indicated by visual observations and field sign (tracks, feces, dens). Each evaluation was recorded as a numerical rating using the following scale: poor, 0.0 - 3.0; fair, 3.1 - 5.0; good, 5.1 - 8.0; excellent, 8.1 - 10.0. The value of a habitat type was rated not applicable (NA) when it was probably not used by a faunal group. Coefficients of variation were calculated for each habitat type (Steel and Torrie 1960) to determine the percent variation among the habitat unit values.

Use of the river by migrating waterfowl was obtained from aerial surveys flown by the South Dakota Department of Game, Fish and Parks. Collection/observation data were also used to evaluate habitats for small mammals and terrestrial birds.

Small mammal population indices in each intensive sampling site were acquired using removal trapping. A six by six grid of stations was laid out; stations were 15 m apart and contained two Museum Special snap traps. The traps were checked and baited nightly for three nights with a mixture of rolled oats and peanut butter (Beer 1964). All captures were expressed as captures per 100 trap-nights and rate of capture was used to compare habitat types.

Habitat values for small mammals were based largely on a comparison of captures per 100 trap-nights made in this study, because studies of these habitat types have not been reported extensively in the literature. The highest number of captures per 100 trap-nights was

given a habitat value of 10, and all other sites were compared to this when determining values. Captures and species composition of small mammals in each habitat type are described in Appendix D.

Avian use of sampling sites was determined by walking along the six 75 m square grid lines used in small mammal sampling, but extending the length of the lines to 100 m. All birds utilizing the sampling area for nesting or feeding were recorded during a two hour period mornings and evenings. Counts were not made during periods of rain, high winds, or when mid-afternoon temperatures exceeded 35 C.

Bird species diversity (BSD) was calculated using the Shannon-Weaver index (Shannon and Weaver 1949). This formula has received widespread use in recent studies of avian communities (MacArthur and MacArthur 1961, Karr 1968, Kricher 1973, Shugart and James 1973, Zimmerman and Tatschl 1975) and was used in this study as the most important factor in determining the value of each habitat to terrestrial birds. The number of species recorded and the average number of birds using each site were also used to determine habitat values. The BSD data from this study were compared to two other avian studies on riparian cottonwood woodlands to determine the highest habitat value, and all other sites were compared to it. The number of species recorded and the average number of birds using each site were also used to determine habitat values. The Shannon-Weaver index and its application are discussed in Appendix E, along with details of avian composition of each habitat and a brief analysis of BSD in relation to succession.



A value was added to the base value assigned each habitat type for interspersion based upon the number of adjoining habitat types and their values (U. S. Fish and Wildlife Service 1976). To determine the interspersion value for each habitat type, aerial photographs were overlaid with a transparency gridded into 16 ha squares. If more than one habitat type occurred within a square or if one habitat type occurred more than once, the base values of all habitat types were added. The total base value of all habitat types within the grid was converted to an interspersion value (Table 2). When interspersion values had been computed on all of the aerial photographs, a mean interspersion value for each habitat type was calculated and added to the base value. The base value, plus its interspersion value, could be multiplied by the total acreage of the habitat being evaluated to determine the overall value in habitat units of that habitat type.

A literature search was conducted to determine the species of mammals, birds, and herptiles which have been reported within the range of the study area. Scientific names of animal species are listed in Appendices F, G, H.

Table 2. Interspersion values per acre added to habitat base value per acre.<sup>a</sup>

Number of Habitat Types in 16-ha Grid	Total Base Value of all Habitat Types in Grid	Interspersion Value to be Added to Base Value
$\geq 1$	NA	0.0
$\geq 2$	0 - 1	0.0
$\geq 2$	2 - 9	0.1 - 0.8
$\geq 2$	10 - 19	0.9 - 1.8
$\geq 2$	20 - 29	1.9 - 2.8
$\geq 2$	30 - 30+	2.9 - 3.0

<sup>a</sup>U. S. Fish and Wildlife Service (1976).

## RESULTS AND DISCUSSION

### Habitat Delineation

Natural habitats comprised 40 percent (12,304 ha) of the total area delineated; agricultural/urban lands accounted for 60 percent (18,726 ha). Cottonwood-dogwood was the most abundant natural habitat, followed by cottonwood-willow, elm-oak, cattail marsh, sand dune, and sand bar (Table 3).

Percentage of sand bar area in Segment 1 was lower than Segments 2 or 3 because the river in Segment 1 was bordered by bluffs and had fewer meanders. Although Segment 3 was stabilized, it had as large a percentage of sand bar area as Segment 2; however, the stable sand bars of Segment 3 resulted from the accumulation of sand behind wing dikes, while the bars in Segment 2 were unstable, shifting as the river channel fluctuated.

Area of sand dune habitat varied from 2 percent in Segment 1 to 6 percent in Segment 3, and probably resulted from sediments deposited by floods prior to the closing of Fort Randall Dam and Gavins Point Dam. Reduction in river velocity caused increased sand deposition on the inside of river meanders (Van Bruggen 1961).

Measurable cattail marsh was found only in Segment 1 near Running Water, where water current velocity decreased. Other cattail stands were in shallow water away from the main channel and near incoming tributaries. Lawrey (1973) reported marshes along the river between Gavins Point Dam and Sioux City, but he did not distinguish between

Table 3. Area of habitat types within 1 km of the Missouri River from Fort Randall Dam, South Dakota, to Sioux City, Iowa.

Habitat Type (Code)	Segment 1 <sup>a</sup>			Segment 2 <sup>b</sup>			Segment 3 <sup>c</sup>			Total		
	Acres	Hectares	%	Acres	Hectares	%	Acres	Hectares	%	Acres	Hectares	%
Sand bar (110)	172	70	d	678	274	2	223	90	2	1,073	434	1
Sand dune (120)	444	180	2	1,066	431	3	777	314	6	2,287	926	3
Cattail marsh (310)	2,523	1,021	10	0	0	0	0	0	0	2,532	1,021	3
Cottonwood- willow (321)	0	0	0	4,157	1,682	11	2,389	967	19	6,546	2,649	9
Cottonwood- dogwood (322)	4,266	1,726	16	6,765	2,738	18	1,351	547	11	12,382	5,011	16
Elm-oak (330)	2,589	1,048	10	1,912	774	5	1,091	444	9	5,592	2,263	7
Agricultural lands (400)	14,834	6,003	56	21,695	8,780	57	6,334	2,563	52	42,863	17,346	56
Urban lands (500)	1,570	635	6	1,728	699	4	111	45	1	3,409	1,380	5
Total	26,398	10,683	100	38,001	15,378	100	12,276	4,970	100	76,684	31,030	100

<sup>a</sup>Fort Randall Dam, South Dakota, to Running Water, South Dakota.

<sup>b</sup>Gavins Point Dam to Ponca State Park, Nebraska.

<sup>c</sup>Ponca State Park to Sioux City, Iowa.

<sup>d</sup>Less than 1 percent.

cattail and cattail-willow-cottonwood habitats. Small cattail marshes in Segment 2 were usually interspersed with islands of willow-cottonwood habitat and chutes, forming a complex mosaic in certain locations. However, high water releases from Gavins Point Dam during the winter of 1975-76 silted in most low areas. This silt will restrict future cattail reproduction and growth.

Cottonwood-willow habitat was absent in Segment 1, but was the second most common natural habitat in Segment 2 and comprised the greatest amount of natural vegetation in Segment 3 (Table 3). The lack of this habitat in Segment 1 may be explained by the limited area of sand bars upon which cottonwood-willow habitat could become established. Much of the cottonwood-willow habitat in Segment 3 was located on stable sand bars behind the wing dams of the stabilized river.

The most abundant natural vegetation in Segment 1 and Segment 2 was cottonwood-dogwood (Table 3). In Segment 3, more cottonwood-willow occurred than cottonwood-dogwood.

Elm-oak habitat occurred in ravines and moist locations on the bluffs in Segment 1, and on the Nebraska bluffs in Segments 2 and 3. This habitat was the second most important in Segment 1, and third most important in Segments 2 and 3.

#### Vegetation Analysis

Sand dune habitat represents a reversion to an earlier stage of succession. Sand deposited by floods covered all vegetation except for larger eastern cottonwoods (0.5 - 3.0 dm DBH). Vegetation

established since flooding consisted of dense stands of cottonwood, sandbar willows, and peach-leaved willows (Tables 4 and 5, Fig. 2). Although species composition of sand dunes was simple, distribution of vegetation was variable. It included expanses of sand with no vegetation; tall cottonwoods over bare sand or with an understory of willows and/or cottonwood saplings; and dense patches of young cottonwoods, willows, and/or alfalfa. Dunes stabilized by trees and shrubs often had a ground cover of alfalfa.

Cattail marshes consisted of monospecific stands of narrow-leaved cattail in sandy, shallow-water areas (Fig. 3) interspersed with cleared waterways. There was little or no submergent vegetation, although some duckweed was observed.

Plant species composition and distribution were more complex in cottonwood-willow habitat (Fig. 4) than in either sand dune or marsh habitats. A complex mosaic was formed from interspersed areas with herbaceous growth, rushes, or horsetail; small ponds with cattail peripheries; extremely dense thickets of willow; and patches of willow/tall cottonwood. Four tree species and six shrub species were recorded (Tables 6 and 7). Peach-leaved willow had the highest importance value for trees, followed by cottonwood, Russian olive, and sandbar willow. Willows and false-indigo were typical shrubs for this habitat and showed the highest importance values.

Although eight tree species were recorded in cottonwood-dogwood habitat (Fig. 5), cottonwood was the most important, exhibiting the highest relative density, dominance, and frequency (Table 8). Slippery

Table 4. Quantitative characteristics of sand dune overstory in the study area.

Species	Relative Density	Relative Dominance	Relative Frequency	Importance Value
Eastern cottonwood	100.00	100.00	100.00	300.00

Table 5. Quantitative characteristics of sand dune understory in the study area.

Species	Relative Density	Relative Frequency	Importance Value
Sandbar willow	62.89	45.50	108.39
Peach-leaved willow	37.11	54.50	91.61
Total	100.00	100.00	200.00





Figure 2. Typical sand dune habitat along the Missouri River near Greenwood, South Dakota.



Figure 3. Typical cattail marsh habitat along the Missouri River at the mouth of Choteau Creek, South Dakota.



Figure 4. Typical cottonwood-willow habitat along the Missouri River near North Sioux City, South Dakota.

Table 6. Quantitative characteristics of cottonwood-willow habitat overstory in the study area.

Species	Relative Density	Relative Dominance	Relative Frequency	Importance Value
Peach-leaved willow	68.33	67.56	22.22	158.11
Eastern cottonwood	21.67	21.62	44.45	87.74
Russian olive	3.33	5.41	22.22	30.96
Sandbar willow	6.67	5.41	11.11	23.19
Total	100.00	100.00	100.00	300.00

Table 7. Quantitative characteristics of cottonwood-willow habitat understory in the study area.

Species	Relative Density	Relative Frequency	Importance Value
Sandbar willow	35.34	25.53	60.87
Peach-leaved willow	28.49	27.66	56.15
False-indigo	20.82	19.15	39.97
Red-osier dogwood	8.77	12.77	21.54
Diamond willow	3.56	8.51	12.07
Wild rose	3.02	6.38	9.40
Total	100.00	100.00	200.00



Figure 5. Typical cottonwood-dogwood habitat along the Missouri River near Vermillion, South Dakota.

Table 8. Quantitative characteristics of cottonwood-dogwood habitat overstory in the study area.

Species	Relative Density	Relative Dominance	Relative Frequency	Importance Value
Eastern cottonwood	41.56	82.54	30.78	154.88
Slippery elm	12.87	4.73	15.38	32.98
Green ash	8.56	3.17	15.38	27.11
Box elder	8.04	1.66	15.38	25.08
Mulberry	11.80	1.94	7.69	21.43
Eastern red cedar	10.73	3.04	3.85	17.62
Peach-leaved willow	4.29	1.82	7.69	13.80
Basswood	2.15	1.10	3.85	7.10
Total	100.00	100.00	100.00	300.00

elm, box elder, and green ash were usually subdominants. Cottonwood was present in most of the Segment 1 sample sites as 20 - 70 cm DBH trees. Slippery elm, box elder, and green ash, although subdominant, were usually present as mature trees. In Segments 2 and 3, however, cottonwood was generally the only mature tree present. Slippery elm, green ash, and box elder were usually recorded in young age classes (0 - 10 cm DBH); indicating a successional trend toward the vegetation recorded in Segment 1.

Although red-osier dogwood was the most important shrub in cottonwood-dogwood habitat, nine shrub species were recorded (Table 9). False-indigo, sandbar willow, and peach-leaved willow were found in young cottonwood-dogwood sites where dogwood occurred at low densities. Black raspberry, smooth sumac, and wild rose typically became established where the forest canopy allowed more light to reach the shrub layer. Gooseberry and tatarian honeysuckle, along with dogwood, were present in the advanced successional stages found in Segment 1.

More tree species were found in the elm-oak habitat (Fig. 6) than in any of the others, and the importance values were more equally distributed (Table 10). Five species had importance values greater than 30: slippery elm, bur oak, box elder, eastern red cedar, and green ash; while only cottonwood and slippery elm had importance values greater than 30 in cottonwood-dogwood habitat.

Five shrub species were recorded in the elm-oak habitat type (Table 11). Gooseberry, red-osier dogwood, and tatarian honeysuckle



Table 9. Quantitative characteristics of cottonwood-dogwood habitat understory in the study area.

Species	Relative Density	Relative Frequency	Importance Value
Red-osier dogwood	86.34	56.15	142.49
Wild rose	9.21	22.81	32.02
Black raspberry	1.94	5.26	7.20
Gooseberry	1.00	3.51	4.51
False-indigo	0.56	3.51	4.07
Tatarian honeysuckle	0.38	3.51	3.89
Sandbar willow	0.19	1.75	1.94
Smooth sumac	0.19	1.75	1.94
Peach-leaved willow	0.19	1.75	1.94
Total	100.00	100.00	200.00



Figure 6. Typical elm-oak habitat along the Missouri River near Maskell, Nebraska.

Table 10. Quantitative characteristics of elm-oak habitat overstory in the study area.

Species	Relative Density	Relative Dominance	Relative Frequency	Importance Value
Slippery elm	27.80	19.72	22.72	70.24
Bur oak	11.28	23.90	18.18	53.36
Box elder	19.86	20.73	4.55	45.14
Eastern red cedar	23.47	10.47	4.55	38.49
Green ash	7.67	7.39	18.18	33.24
Basswood	3.61	11.41	0.09	24.11
Kentucky coffeetree	1.80	3.85	9.09	14.74
Honey locust	2.71	1.35	9.09	13.15
Black walnut	1.80	1.18	4.55	7.53
Total	100.00	100.00	100.00	300.00

Table 11. Quantitative characteristics of elm-oak habitat understory in the study area.

Species	Relative Density	Relative Frequency	Importance Value
Missouri gooseberry	66.35	51.61	117.96
Red-osier dogwood	20.38	22.58	42.96
Tatarian honeysuckle	11.85	19.35	31.20
Smooth sumac	0.95	3.23	4.18
Black raspberry	0.47	3.23	3.70
Total	100.00	100.00	200.00

were the most common species present. Smooth sumac and black raspberry occurred in disturbed areas.

Vines were common in cottonwood-dogwood and elm-oak habitat (Table 12). Virginia creeper, riverbank grape, and poison ivy formed a dense ground cover, often 1 m high, in the cottonwood-dogwood sites. These species were also common as arboreal lianas. Vines were limited to arboreal forms in elm-oak habitat; greenbriar, Virginia creeper, and riverbank grape were the most common species.

I believe that elm-oak habitat would support many more shrub species, ground covering vines, and other vegetation without heavy grazing. Elm-oak habitat was grazed by cattle because it existed on steep topography covered with thin soils not conducive to clearing and cultivating. In addition to the reduction of shrub density and diversity, grazing by cattle removed most of the ground cover, leaving only a thin to moderate layer of leaves. Dambach (1944) reported that seedlings, shrubs, and herbaceous vegetation in woodlots were removed by grazing within one season. I found a lack of extensive understory in elm-oak habitat; some early seedlings were present but no saplings or younger trees.

Composition of elm-oak habitat was similar to the xeric climax community along the channelized Missouri River south of Sioux City, Iowa. Vaubel and Hoffman (1975) found this community dominated by bur oak and shagbark hickory, with slippery elm and basswood as other important tree species. They found that gooseberry formed a shrub union with wolfberry, which I did not find in my study area. Virginia

Table 12. Frequency of vines in eight sample sites of cottonwood-dogwood and five sample sites of elm-oak habitats.

Species	Cottonwood-dogwood	Elm-oak
Bittersweet	12.5	0.0
Greenbriar	12.5	60.0
Moonseed	0.0	20.0
Poison ivy	87.5	0.0
Riverbank grape	87.5	40.0
Virginia creeper	100.0	60.0

creeper was a common vine and poison ivy was absent (Vaubel and Hoffman 1975); both of these conditions also existed in the elm-oak habitat.

A phenogram (Fig. 7) depicts the relationships within and between habitat type groups. Most of the sampling sites within one habitat type are clustered (sand dune, cottonwood-dogwood, and elm-oak), and the proximity of one cluster to another represents a successional relationship.

Sand dune sites were identical ( $R_0 = 1.00$ ), and were most similar in vegetative composition to three of the cottonwood-willow habitats. The species composition of cottonwood-willow sites is successional intermediate between the less complex sand dune habitat and cottonwood-dogwood habitat. Two cottonwood-willow sites with red-osier dogwood present clustered nearer to the cottonwood-dogwood cluster than to the sand dune/cottonwood-willow cluster. Since the dominant tree in both clusters was cottonwood, computer discrimination between them was based on shrub species composition.

The lowest overlap occurred between the elm-oak stands and the remaining sampling sites. This low overlap was a result of the absence of cottonwood on elm-oak sites. The elm-oak sites exhibited lower overlap values within their habitat cluster than the other clusters. Sites in the other clusters were dominated by cottonwood, while sites in the elm-oak cluster had more diversity in both species and sizes of trees.

Vegetation along the unchannelized Missouri River is composed of a successional gradient from cattail marsh to a climax dominated by

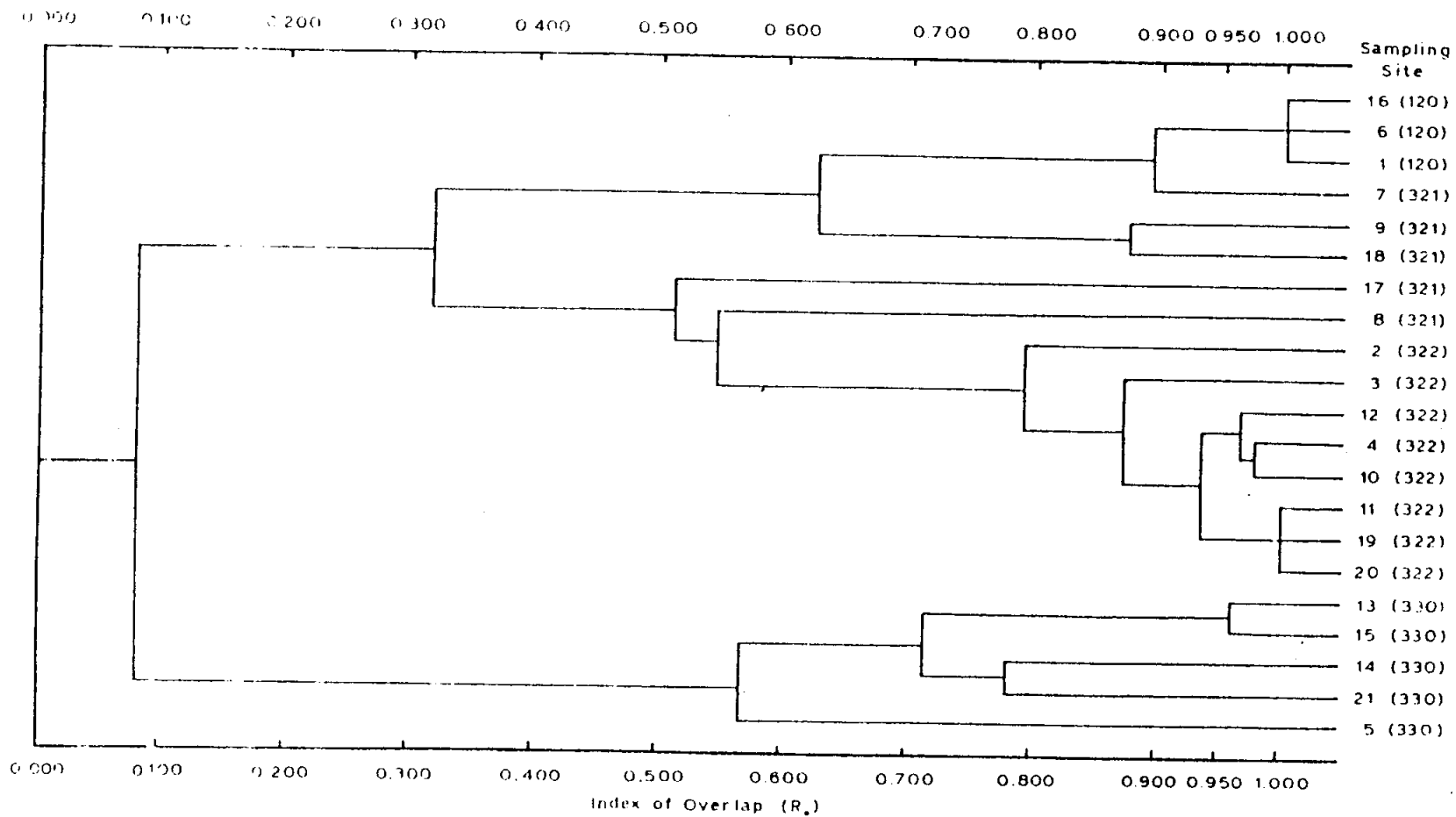


Figure 7. Phenogram of cluster analysis using tree basal areas and shrub densities from 21 sampling sites. The habitat type code of each site is: 120 - Sand Dune, 321 - Cottonwood-willow, 322 - Cottonwood-dogwood, 330 - Elm-oak.



slippery elm and bur oak. Although the five habitats examined may have stages intermediate to them, these were quantitatively separable and visually detectable on aerial photographs. For these reasons, they were felt to be suitable for use in this study.

#### Habitat Type Evaluation

The following section will be devoted to discussions of the requirements of each of the faunal groups as found in the literature and collections/observations on use of each habitat; these will then be discussed in their relation to habitat evaluation of each faunal group. Each habitat provided the necessary requirements of food, shelter, and water for a faunal group in varying degrees (Table 13). The values of each habitat type to all faunal groups are separated into average values for Segments 1, 2, and 3 in Appendix I.

Although sand bar habitat was not sampled because it was subject to changes caused by the river, it was important in providing feeding sites for breeding and migrating shorebirds and resting sites for migrating waterfowl. Killdeer, upland sandpipers, and spotted sandpipers were probable summer breeders that searched for invertebrates on mudflats and sandbars. Aerial censuses flown by the South Dakota Department of Game, Fish and Parks (letter dated 21 January 1977 from John W. Koerner, U. S. Fish and Wildlife Service, South Dakota-Nebraska Area Office, Pierre, South Dakota) indicated use of the river between Fort Randall Dam and Sioux City by migrating waterfowl (Table 14). Waterfowl utilized the sandbars in the river as loafing areas, and

Table 13. Wildlife habitat unit values for five habitat types identified on the study area.

Faunal Groups	Habitat Type				
	Sand dune	Cattail marsh	Cottonwood-willow	Cottonwood-dogwood	Elm-oak
Big game animals	4.7	3.5	8.4	8.0	7.2
Upland game mammals	3.3	NA	5.6	7.3	7.2
Furbearers	3.7	8.5	6.4	7.1	5.8
Small mammals	3.9	NA	5.2	7.4	3.9
Upland game birds	3.7	NA	7.8	7.7	6.4
Waterfowl	NA	8.0	2.0	NA	NA
Other water and marsh birds	NA	8.0	5.0	NA	NA
Terrestrial birds	5.7	NA	6.0	7.9	5.3
Reptiles and amphibians	5.7	8.5	6.8	4.3	3.6

Table 14. Average waterfowl censuses of weekly Missouri River aerial surveys flown between Fort Randall Dam, South Dakota, and Sioux City, Iowa, from mid-October to 1 December. The river segment between Fort Randall Dam and Gavins Point Dam includes Lewis and Clark Lake<sup>a</sup>.

River Segment	Geese				Ducks			
	1973 <sup>b</sup>	1974 <sup>c</sup>	1975 <sup>d</sup>	1976 <sup>c</sup>	1973 <sup>b</sup>	1974 <sup>c</sup>	1975 <sup>d</sup>	1976 <sup>c</sup>
Fort Randall Dam to Gavins Point Dam	225	70	5	680	40,000	54,600	44,070	73,350
Gavins Point Dam to Sioux City, Iowa	8	25	270	5	180	220	390	595
Total	228	95	275	685	40,180	54,820	44,460	73,945

<sup>a</sup>Letter dated 21 January 1977 from John W. Koerner, U. S. Fish and Wildlife Service, South Dakota-Nebraska Area Office, Pierre, South Dakota.

<sup>b</sup>Based on six censuses.

<sup>c</sup>Based on eight censuses.

<sup>d</sup>Based on seven censuses.

were a source of hunter recreation. The loss of sand bars would mean a loss of resting areas for ducks and geese.

Sand Dune Habitat.--White-tailed deer and mule deer probably used sand dune habitat for feeding. Mule deer occurred along the river, particularly in Segment 1 on the Nebraska side. Willows were abundant in sand dune habitat, and have been reported as a moderately important food source for deer (Martin et al. 1961). Kohn and Mooty (1971) stated that the most important factor determining deer use of an area during the summer was the availability of preferred food species. The general lack of ground cover probably precluded the use of sand dunes for bedding sites or as winter cover. Tracks were recorded in one of the three sampling sites, indicating that these areas were used in the summer. Sand dune habitat was given a fair (4.7) rating for big game.

Fox squirrels and eastern cottontails were upland game mammals on the study area. Only young cottonwood trees occurred on sand dune habitat and no mast or nesting cavities were present. In addition, the lack of leaf nests indicated that this habitat was not used by fox squirrels. Hibbard (1972) reported squirrels absent or rare in young to medium-aged cottonwood forests along the Missouri River in North Dakota.

Food and cover were scarce for cottontails. Alfalfa, used to some extent as food by cottontails (Martin et al. 1961), was present in patches. These localized areas of alfalfa may also have provided cover during the summer months; but not during the winter. The value of

sand dune habitat for upland game mammals was fair (3.3).

Furbearers using this habitat probably included coyotes, red foxes, gray foxes, and opossums. I recorded coyote and fox tracks at one site. These species probably used the areas for feeding purposes. Food of coyotes and foxes in the Midwest consists of rabbits and small rodents (Fichter et al. 1955, Gier 1957, Korschgen 1957), both of which were present in sand dune habitat. The soft sand characteristically found in this habitat type, however, would not be conducive to den construction (Gier 1957, Storm et al. 1976). Opossums are omnivorous and opportunistic (Reynolds 1945, Martin et al. 1961), but primarily feed on invertebrates and carrion. Both of these foods could be found in sand dune habitat, but only in limited amounts. Sand dunes were considered fair (3.7) habitat for furbearers.

Sand dune habitat was fair (3.9) for small mammals. Although captures per 100 trap-nights were high (Table 15), they did not reflect the overall habitat quality. Trapping grids in the three sampling sites were placed so that both bare sand and patches of alfalfa were sampled. These patches of alfalfa consisted of vegetation 0.5 m to 1.0 m high forming localized areas of complete ground cover which apparently provided good conditions for mouse populations. Much of the sand dune habitat was not covered with alfalfa, however, so the expected value of each sand dune site was decreased by one-half.

Sand dunes were of fair (3.7) value to upland game birds (ring-necked pheasants and mourning doves). Cultivated grains are the most important food source of the pheasant, with corn comprising the

Table 15. Small mammal captures per 100 trap-nights (TN) and habitat values for 21 sampling sites.

Habitat Type	Number of Sites	Captures/100 TN	Habitat Value
Sand dune	3	11.62	3.5
		10.87	3.5
		18.06	4.7
Cottonwood-willow	5	3.70	3.0
		5.56	5.0
		4.17	4.0
		15.28	8.0
		7.48	6.0
Cottonwood-dogwood	8	11.62	7.0
		14.81	7.5
		26.39	10.0
		25.00	10.0
		8.57	6.5
		5.71	5.0
		5.56	5.0
		15.28	8.0
Elm-oak	5	6.28	5.5
		1.85	2.0
		4.33	4.0
		2.31	2.0
		6.94	6.0

bulk of their diet (Korschgen 1964, Gates and Hale 1974). Wheat or oats may also be important in the seasonal diet of pheasants. Because natural foods play a minor role in the pheasant diet where cultivated grains are present, none of the habitat types were considered a valuable source of food. Nesting by pheasants is often extensive in alfalfa (Trautman 1960, Baxter and Wolf 1973), but the small patches found in sand dune habitat were not suitable for nesting. The sand dune habitat did not provide quality winter cover. Pheasant tracks were recorded in these areas, however, and probably resulted from use of the areas to obtain grit.

Mourning doves received little food value from sand dune habitat, because there were few grasses or forbs to provide a seed source. Doves have been reported to avoid nesting in cottonwoods because their open canopy exposed suitable forks to wind and rain (Boldt and Hendrickson 1952, LaPointe 1958). Mourning doves observed using these areas may also have been ingesting grit.

Bird species diversity values in homogenous riparian cottonwood sites in Arizona ranged from 2.53 to 2.98 (Carothers et al. 1974). Reanalysis of avian data reported by Walcheck (1970) for riparian cottonwood woodland in Montana yielded a BSD value of 3.01. The highest BSD calculated for similar habitat in my study (cottonwood-dogwood) was 2.47, which was lower than those reported in Arizona and Montana. The habitat value of this site was determined to be 8.5, and all other sites on the study area were compared to it (Table 16).

Sand dunes were considered good (5.7) habitat for terrestrial

Table 16. Avian data and habitat values for 21 sampling sites.

Habitat Type	BSD	Number of Species/Site <sup>a</sup>	Number of Birds/Site <sup>b</sup>	Habitat Value
Sand dune	2.23	15(2)	19.00(2)	7.0
	1.39	8(4)	7.80(4)	2.0
	2.16	15(4)	15.50(4)	5.0
Cottonwood-willow	1.71	12(4)	9.25(4)	3.0
	2.05	22(4)	22.25(4)	6.0
	2.17	25(4)	18.25(4)	6.0
	2.31	18(4)	22.25(4)	8.0
	2.23	21(4)	19.25(4)	7.0
Cottonwood-dogwood	2.39	15(2)	38.00(2)	8.5
	2.41	16(2)	34.00(2)	8.5
	1.68	13(3)	14.00(3)	4.0
	1.98	12(2)	22.50(2)	5.0
	2.23	18(4)	23.40(4)	7.0
	2.07	14(4)	22.50(4)	5.0
	2.32	17(3)	25.00(3)	7.5
	2.47	22(3)	39.33(3)	8.5
Elm-oak	1.82	13(4)	13.00(4)	3.0
	2.38	19(2)	31.50(2)	8.0
	2.30	16(3)	17.30(3)	7.5
	1.73	9(4)	11.75(4)	3.0
	1.99	18(4)	16.50(4)	4.0

<sup>a</sup>Total number of species recorded for each sampling site.

<sup>b</sup>Average number of birds observed using each sampling site. The number of censuses used to record these values is in parentheses.



birds. Bird species diversity values ranged from 1.39 to 2.33 (Table 16). Cottonwoods and dense willow thickets provided nesting locations, but plant distribution on the bare sand was patchy. This patchiness resulted in areas of bare sand interspersed with sparsely foliated, poor quality nesting/foraging habitat and good quality habitat.

Cottonwood dominated habitat downstream from Fort Randall Dam and Gavins Point Dam has been reported as an important wintering area for northern bald eagles (Grewe 1966, Steenhof 1976). The eagles were attracted by large cottonwoods, an abundant food supply, and open water throughout the winter. Steenhof (1976) emphasized the importance of large cottonwood trees as roosting sites, even though these trees constituted a lower proportion of the floodplain vegetation below Fort Randall Dam than other species. Large diameter cottonwood trees were present in sand dune areas, so the value of this habitat to terrestrial birds was increased by 1.0 point.

Sand-dwelling herptiles such as the great plains toad and eastern hognose snake were collected or observed in two of the three sand dune sample sites. Tracks of these species were abundant. Since the toads feed on insects and hognose snakes feed on toads, all the necessary life requirements were present. The lack of diversity among reptiles and amphibians prevented a higher rating than 5.7.

Cattail Marsh Habitat.--Cattail marshes were considered of fair (3.5) value to white-tailed deer because they provided winter cover.

Deer tracks were observed on a sandy bank at one site during the summer, which may indicate other than winter use.

Cattail marsh habitat was excellent (8.5) for two aquatic furbearers: muskrats and minks. Marshes consisted of dense cattail stands with open waterways probably created by muskrats, which use cattails for food and lodge-building (Weller and Spatcher 1965). Annual spring flooding of cattail areas provides ideal breeding conditions, litter survival, and juvenile dispersal each year. Muskrat lodges were observed in both sampling sites, and food caches and tracks were observed.

Korschgen (1958) reported that frogs, fish, white-footed mice, deer mice, and rabbits were the major prey species of mink in Missouri. Errington (1954) reported that mink usually preyed upon frogs and crayfish, but muskrats became more important under conditions of drought or overpopulation. All of these prey items were present in marshes, making this habitat suitable for mink.

Waterfowl used marshes (8.0 habitat value) during the summer for breeding and during spring and fall for resting areas. Probably because of the lack of adequate aquatic vegetation other than cattail, lesser scaup was the only breeding waterfowl observed. Lesser scaups feed primarily on aquatic invertebrates in diverse depths of water (Bellrose 1976). Cattail marshes became more important during the spring and fall when they were used as resting areas for migrating waterfowl. While verifying habitat types in spring 1976, I observed mallards, pintails, blue-winged teals, shovelers, American wigeons,

there. Most of these species, however, were found in only one or two sample sites. For example, signs of muskrat, mink, and beaver were restricted to two sample sites. A small pond was located on one of these sites and an oxbow slough on the other; standing water did not occur on the other three sampling sites. Observations of activities of terrestrial furbearing species were scattered throughout the five sampling sites.

Den sites were probably available for terrestrial furbearers as the sandy soil was suitable for den construction. Fallen or hollow logs commonly used as den sites by raccoons (Gysel 1961) were not available. Food was probably the limiting factor for coyotes, skunks, and raccoons. Small mammals and cottontails constitute the primary food of coyotes (Korschgen 1957), but were not present in high numbers. The major food sources of raccoons in eastern Iowa were corn, berries, and insects (Giles 1940). Corn and berries were not available in this habitat, and insects could not be expected to comprise their entire diet.

Cottonwood-willow was considered good (5.2) habitat for small mammals. Captures per 100 trap-nights varied from 4.17 to 15.28, resulting in a range of habitat values from 3.0 to 8.0 (Table 15). The lowest value occurred in a dense stand of willows with no litter but a dense stand of horsetails. Dead cattails on three sides of the willow stand indicated that the nearby area had probably been flooded during the previous year, preventing small mammal dispersal into the sampling area. The highest value occurred in a moderately dense stand of cottonwoods with few willows but a dense ground cover of

horsetails. The variation in captures per 100 trap-nights probably resulted from the differences in microhabitat on the sampling sites and the difficulty in locating similar ground vegetation throughout the study area in which to place the trapping grids.

Cottonwood-willow habitat was good (7.8) for upland game birds. Pheasants and mourning doves were seen or heard on all five sampling sites. In Wisconsin, shrub-carr habitat was important to pheasants in all seasons (Gates and Hale 1974). Shrub-carr habitat, quite similar to the cottonwood-willow of this study, was composed of willow and/or dogwood, sedges, bluejoint grass, and mixed lowland forbs (Gates 1970). The shrubby vegetation was important as winter loafing cover and, to a lesser extent, as roosting cover, especially when snow depths exceeded 30 cm. Open areas of cottonwood-willow habitat were also important in the establishment of spring crowing areas. Gates (1971, cited by Gates and Hale 1974), reported that 63 percent of all brood production occurred in wetlands, although the broods generally moved to uplands for rearing.

Mourning doves utilized the cottonwood-willow habitat. Walcheck (1970) found that mourning doves nesting in cottonwood forests utilized a variety of plant life forms along the Missouri River in Montana. The cottonwoods in cottonwood-willow habitat visually appeared taller and more densely foliated than those in sand dune habitat, and were probably utilized for nesting by doves. Because of its value to mourning doves as nesting habitat and its probable value to pheasants

all year, cottonwood-willow habitat was considered good (7.8) habitat for upland game birds.

Wood ducks used a pond located on one cottonwood-willow site for feeding, and one brood of blue-winged teal was observed on another. Cottonwood-willow habitat was considered to be of poor (2.0) value to waterfowl since these were the only observations of them.

Cottonwood-willow habitat was of fair (5.0) value to other water and marsh birds because it was generally too dry to provide suitable habitat for any species except those which nest in trees, such as red-winged blackbirds, yellowthroats, and herons. Yellowthroats probably found all of their life requirements in this habitat. Their diet is composed largely of insects and their territories were established in willow thickets. Red-winged blackbirds probably nested in this habitat but gathered food elsewhere. Their major foods are corn, oats, and foxtail (Martin et al. 1961). Similarly, great blue herons probably used the area for nesting; their fish diet would require use of shallow-water areas along the river for feeding. Northern green herons and black-crowned night herons were not observed, but probably utilized cottonwood-willow habitat.

Cottonwood-willow was good (6.0) quality habitat for terrestrial birds. Bird species diversity was fairly consistent, and habitat values for all but one site were between 6.0 and 8.0 (Table 16). The one exception (3.0) was located in a site where BSD was low. This area consisted of a dense stand of willows and an open field. Few cottonwoods were in the area to provide nesting sites. Thirty-seven

species nesting and feeding in the many microhabitats found in cottonwood-willow communities included waterfowl, marsh birds, ground nesters, shrub nesters, and tree nesters. A higher rating than 6.0 was not given because densities and frequencies of many species were low.

Cottonwood-willow habitat was good (6.8) for herptiles, especially in moist areas. Five leopard (meadow) frogs were observed and cricket frogs were too numerous to count. Snapping turtles, great plains toads, American toads, and a red-sided garter snake were also observed in this habitat. Only a few individuals of the last four species were observed, and each species was recorded at only one site. Under wetter conditions, this habitat would probably have been of more value to herptiles (Fishbeck 1959); however, the present drought left much of this habitat too dry for many species.

Cottonwood-dogwood Habitat.--Cottonwood-dogwood was considered excellent (8.0) habitat during summer and winter for white-tailed deer because of the abundance of red-osier dogwood as a source of food. Dogwoods of various species have been reported as important deer browse (Webb 1959, Martin et al. 1961). Although dense thickets were not usually present in this habitat, shrubs and trees provided shade during the summer and protection in the winter. Deer and their tracks were not readily seen because of the density of vegetation and ground cover; however, a total of six deer was observed in two of the eight sites sampled. Hibbard (1972) found similar habitat used heavily by deer in North Dakota along the Missouri River.

Cottonwood-dogwood was the most important habitat to upland game mammals. Although squirrel habitat was poor in Segments 2 and 3, the sites below Fort Randall Dam were excellent. Mature elm trees killed by Dutch elm disease provided suitable locations for dens. Buds and seeds of elm have been recorded as a staple food in Illinois (Brown and Yeager 1945), and were probably an important food source in Segment 1.

Cottontails were abundant in cottonwood-dogwood habitat; a total of twelve was observed on four of the eight sampling sites. Vines provided excellent cover when foliage was present, and thickets of gooseberry and young honey locust provided winter protection from predators. Cottontails probably fed on legumes and forbs in open areas where the forest had been disturbed and consumed dogwood bark and young twigs during the winter. Because of the heavy use of this habitat by cottontails and the apparent value of Segment 1 sample sites for fox squirrels, it was considered good (7.3) for upland game mammals.

Cottonwood-dogwood habitat was thought to be valuable to red foxes, gray foxes, coyotes, raccoons, and opossums. Den sites for red foxes (Storm et al. 1976) and coyotes (Gier 1957) have been recorded in forests or brush covered areas, so the vegetation of cottonwood-dogwood habitat probably provided suitable denning locations. Cottontails, mice, and rats were abundant in this habitat type and provided a prey base for coyotes, red foxes, and gray foxes. The presence of canids was evident as captured mice were frequently mutilated and traps were often removed from the trapping stations.

Hibbard (1972) reported that coyotes and foxes used all areas for feeding in cottonwood habitat in North Dakota.

Raccoons and opossums probably found den trees in cottonwood-dogwood stands of Segment 1, where older cottonwoods and diseased elms were subject to decay. Younger cottonwood-dogwood stands did not provide these sites. Berries and insects were food sources for raccoons. Although tracks were not readily apparent because of ground cover, I did record one opossum track. Hibbard (1972) reported that raccoons used mature cottonwood-elm sites in North Dakota, but the opossum is not found that far north (Hall and Kelson 1959). Cottonwood-dogwood habitat was good (7.1) for furbearers, and would have been rated higher if the sites in Segments 2 and 3 had been suitable for raccoon and opossum dens.

Cottonwood-dogwood was considered the best small mammal habitat in the study area. Captures per 100 trap-nights were above 10.0 in five of eight sampling sites, and were 25.0 or greater in two (Table 15). These areas had a good ground cover of either heavy leaf litter (Segment 1) or ground vines (Segments 2 and 3) providing important cover from predators. Two of the three sites with fewer captures were younger cottonwood stands with a sparse ground cover and less leaf litter than the other sites. Small mammal populations were larger in older cottonwood stands than younger ones, but overall this habitat was good (7.4) for small mammals.

Cottonwood-dogwood habitat was considered good (7.7) for upland game birds. Ring-necked pheasants use woodlots infrequently when



shrubby cover is available (Gates and Hale 1974), but I heard cocks crowing on two of the eight sampling sites. Bobwhite quail were also heard at two sites in Segment 1 where groups of dead elm trees opened the forest canopy allowing small clearings to occur. These clearings offered cover for bobwhite nests, which are usually built on the ground in moderate grassy cover (Rosene 1969). Legume seeds, which form a major portion of the diet, were also present in the clearings. Cottonwood-dogwood was of most value to mourning doves. Riparian cottonwood forests in Montana (Walcheck 1970), North Dakota (Hibbard 1972), and Kansas (Zimmerman and Tatschl 1975) are important nesting areas for mourning doves. In this study, doves were observed nesting or feeding in all sampling sites of the cottonwood-dogwood habitat type. I rated cottonwood-dogwood habitats as good (7.7) upland game bird habitat.

Cottonwood-dogwood was good (7.9) habitat for terrestrial birds. Although BSD and habitat values varied (Table 16), most of the sites were good or excellent. Fewer species (34) were recorded here than in cottonwood-willow habitat, reflecting the more uniform vegetation. Lower habitat values were assigned to sites having younger-aged cottonwood stands, in which ground cover in the form of vines was sparse and shrub density was low. Highest habitat values (8.5) were recorded on three cottonwood-dogwood sites. Two of these were in older cottonwood-dogwood stands in Segment 1, where mature elm and green ash formed an additional vegetation layer below the tallest layer of mature cottonwoods and above the shrub layer. The third site, with

the highest BSD value, average number of birds, and species recorded, had a fourth layer of vegetation consisting of mulberry trees, the fruits of which are an important source of early summer foods to birds (Martin et al. 1961). Like sand dune habitat, the value of 7.9 included 1.0 point reflecting the importance of large cottonwood trees to wintering bald eagles as roosting trees.

Cottonwood-dogwood habitat was too dry for amphibians, and many of the sites provided little cover for reptiles. Only one species was located, a prairie rattlesnake. Other species of snakes probably lived in the vines and leaf litter, but logs and rock piles commonly used for shelter were not abundant. This habitat type was rated fair (4.3) in value to herptiles.

Elm-oak Habitat.--Elm-oak habitat was of good (7.2) value for white-tailed deer. Although grazing reduced understory and ground cover (Table 11, Fig. 7), red-osier dogwood was present as deer food, as were leaves and mast from bur oak. Oak mast has been reported as an important fall and winter deer food (Christisen and Korschgen 1955, Martin et al. 1961). Although grazing reduced the amount of shrubs available for bedding sites and winter cover, the steeper portions were fenced from livestock and these brushy areas were used by deer. A total of ten deer was observed in or near three of the five elm-oak sampling sites; visibility was high because of the reduced understory density.

Upland game mammals occurred in elm-oak communities, which were rated as good (7.2) habitat. Fox squirrels probably found this

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habitat type more valuable than any other habitat. Most of the sampling sites contained large diameter oaks or elms, which are important for denning (Brown and Yeager 1945). Bur oak is a preferred acorn forage of fox squirrels (Smith and Follmer 1972). A total of seven fox squirrels was seen in two of five elm-oak sampling sites.

Cottontails consumed the bark and twigs of dogwood bushes during the winter and remained near ungrazed clearings for summer feedings and nesting. Gooseberry thickets provided protective winter and summer cover. A total of seven cottontails was flushed from these thickets on three sampling sites.

Elm-oak habitat was of good (5.8) value for terrestrial furbearers. Jones (1964) reported bobcats in forested areas along the Missouri River in northern Nebraska, and Korschgen (1957) reported them in heavy forest cover with thick underbrush, clearings, and rocky cliffs. Fenced areas on steep bluffs provided these conditions for the bobcat in elm-oak habitat. In Missouri, the primary foods of the bobcat were rabbit, fox squirrel, deer, and wild turkey (Korschgen 1957). These species probably existed in adequate numbers on my study area to sustain a bobcat population.

Denning requirements for foxes, raccoons, coyotes, and opossums were probably present in this habitat, and coyotes (Gier 1957), raccoons (Giles 1942), and bobcats (McCord 1974) have been reported as using steep, rocky bluffs as occurred here for denning. Grazing activities reduced the ground cover so severely that small mammal populations (mice) were low and most carnivores were provided poor quality hunting

cover. If the prey base had been larger, this habitat would have been rated higher for terrestrial furbearers than it was.

Elm-oak was fair (3.9) quality habitat to small mammals. Captures per 100 trap-nights were lowest in this habitat (Table 15), and only white-footed mice were captured. Other studies have indicated that the density of small mammal populations is highest during late stages of vegetative succession (Wetzel 1958, Pearson 1959). This increase is attributed to several factors (Wetzel 1958): (1) drier soil providing better habitat for burrowing and tunnelling, (2) an increase in litter for potential home sites, and (3) an increase in plant and invertebrate food as plant species diversify. Only the first two factors were met on elm-oak sites in this study. The last factor was disrupted by cattle grazing which reduced shrub density and herbaceous cover. Thus, the presence of a seed source for granivores, such as white-footed mice, was reduced. Short-tailed shrews were absent from elm-oak habitat because of the lack of invertebrates as a food source. Dambach (1944) found a decrease in soil/litter invertebrates from 5.7 million/ha in an ungrazed woodlot to 2.0 million/ha in a heavily grazed woodlot. He attributed this decrease to a reduction in leaf litter, a reduction in low growing green plants, and the instability of the litter, which was more likely to be blown away by the wind with no vegetative cover.

Upland game birds using elm-oak habitats were mourning doves and wild turkeys. Although some mourning doves nested in this habitat, they were not as numerous nor as frequently observed as in either of the cottonwood dominated habitats. Use of elm-oak habitat by doves

was not influenced by the change in canopy composition, but the availability of food types. Most of the cottonwood habitat was on the floodplain terrace near cultivated lands which provided a source of corn. The lack of cultivated lands adjacent to most of the elm-oak habitat forced these birds to rely on native grasses and forbs for seeds, which were in limited supply because of livestock grazing. This lack of food probably reduced the number of doves utilizing the area.

Eastern wild turkeys were present, but it was difficult to ascertain their abundance. Although several landowners reported turkeys on their property, only one was observed on five sampling sites. The staple diet of turkeys in Missouri is acorns, followed closely by grass and sedge leaves (Korschgen 1967). Both of these foods were present in elm-oak habitat. Grass and sedge leaves are utilized primarily in the spring and summer seasons, and little competition with grazing livestock exists until July. Cover, described by Korschgen (1967) as thickets of conifers or dense clumps of grass, was not abundant in this habitat. The lack of cover was the result of livestock grazing, which caused the destruction of nests and nesting cover. The value of elm-oak habitat for mourning doves and the value for turkeys resulted in a good (6.4) rating.

Elm-oak habitat was fair (5.3) for terrestrial birds and had the lowest evaluation rating for that faunal group. Three of the five sampling sites had low BSD values and were rated below 4.0 (Table 16). Although these sites had a fairly complete canopy formed by the

overstory, grazing removed most shrubs and ground cover. Dambach and Good (1940) reported that grazing reduced the number of ground and shrub nesting species. The decrease in ground and shrub nesters on elm-oak sites resulted in lower BSD values. Habitat values and BSD values in the two other elm-oak sites were high (Table 16). These areas had a medium density shrub layer of gooseberry and young honey locust trees, which were thorny species apparently not palatable to livestock. The shrub layer formed by these plants provided additional nesting sites and foraging locations. Short, bushy eastern red cedar trees in elm-oak habitat below Fort Randall Dam are frequently used as bald eagle roosts during bad weather (Steenhof 1976), so 1.0 habitat evaluation point was added to the terrestrial birds rating in each elm-oak site located in Segment 1.

Elm-oak habitat was fair (3.6) in value to herptiles. Like the cottonwood-dogwood habitat, this habitat was too dry to support life for amphibians. Only one reptile was recorded on five sampling sites, an eastern milk snake. The low rating was again the result of grazing, which reduced the number of small rodents used as food and the amount of protective cover.

Cattail marsh had the highest mean base habitat value (7.8), followed by cottonwood-dogwood (7.0), cottonwood-willow (6.5), elm-oak (5.8), and sand dune (4.4) (Table 17). With the exception of sand dune habitat (22.7 percent), coefficients of variation were under 13 percent (Table 17). The high coefficient of variation for sand dune habitat occurred because two of the sites exhibited much higher

Table 17. Base habitat values and coefficients of variation for five habitat types in the study area.

Habitat Type	Mean Value $\pm$ 1 S.D.	Coefficient of Variation
Cattail marsh	$7.8 \pm 1.0$	12.8%
Cottonwood-dogwood	$7.0 \pm 0.4$	5.7%
Cottonwood-willow	$6.5 \pm 0.7$	10.8%
Elm-oak	$5.8 \pm 0.7$	12.1%
Sand dune	$4.4 \pm 1.0$	22.7%

values (6.0 and 5.1) than the third (3.2). The third site occurred on an area much larger than the other two, and contained a greater proportion of bare sand which did not support vegetation suitable as cover or food for wildlife.

Total values for each habitat obtained by adding interspersions values to base habitat values are located on Table 18. Because interspersions values tended to be relatively constant for each habitat type, the order of importance each habitat contributed toward wildlife did not change and each type increased by approximately 1.0.



Table 18. Calculation of total habitat values per acre for five habitats on the study area.

Habitat Type	Base Habitat Value	Interspersion Value	Total Habitat Value
Cattail marsh	7.8	1.1	8.9
Cottonwood-dogwood	7.0	0.9	7.9
Cottonwood-willow	6.5	1.0	7.5
Elm-oak	5.8	0.9	6.7
Sand dune	4.4	0.9	5.3

## CONCLUSIONS

Eight habitats were identified, delineated, and measured within 1 km of the unchannelized Missouri River between Fort Randall Dam, South Dakota, and Sioux City, Iowa. Sixty percent of the area measured was occupied by agricultural or urban developments. The remaining area was composed of six habitat types: sand bar, sand dune, cattail marsh, cottonwood-willow, cottonwood-dogwood, and elm-oak. A wide variety of plant forms existed in these areas, providing suitable habitat for an equally wide variety of wildlife species.

Sand bars are important resting areas for migrating waterfowl. They also provide feeding locations for breeding shorebirds such as killdeer, upland sandpipers, and spotted sandpipers.

Sand dune habitat was vegetated with eastern cottonwood and willows, but the bare sand substrate provided generally poor wildlife habitat. Terrestrial birds made moderate use of the tree/shrub vegetation, and sand-dwelling herptiles such as hognose snakes and great plains toads were often numerous.

Cattail marshes were dominated by narrow-leaved cattail growing in shallow, slow-moving water. This habitat was excellent for aquatic furbearers such as muskrat and mink, providing both food and cover. Diving ducks such as the lesser scaup were probably the only breeding waterfowl using this habitat because of the lack of aquatic vegetation. Cattail marshes provided valuable resting cover for migrating mallards, pintails, blue-winged teals, and other waterfowl. Other water and

marsh birds recorded using this habitat were great blue herons, red-winged blackbirds, yellow-headed blackbirds, common grackles, Forster's terns, and American coots. Turtles and frogs were abundant herptiles in this habitat.

Cottonwood-willow was excellent habitat for big game, and received much use by white-tailed deer. Upland game birds (ring-necked pheasants and mourning doves) were abundant; nesting cover was provided for both species and excellent winter cover was available for pheasants. The interspersed of trees, shrubs, forbs, grasses, and ponds provided suitable habitat for a wide variety of uses by the seven other faunal groups. Cottonwood-willow was the only habitat which was of value to all nine faunal groups studied.

Cottonwood-dogwood habitat provided good to excellent habitat to all of the faunal groups found there except herptiles. Big game (white-tailed deer and mule deer) fed on preferred foods (red-osier dogwood) and found adequate cover. Terrestrial birds were most abundant and most diverse in cottonwood-dogwood habitat, where they found three to four layers of vegetation for nesting and feeding.

Grazing reduced the value of elm-oak habitat to most forms of wildlife, but oak mast provided food for big game and fox squirrels, which were abundant upland game mammals. Elm-oak habitat was of low value to small mammals and herptiles because of the extensive removal of ground cover by grazing.

The six habitats along the unchannelized Missouri River were important to wildlife for two reasons. First, each habitat provided

a set of life requirements to which certain faunal groups were adapted more than other habitats. This made each habitat optimal for different wildlife species. Second, the diversity of vegetational life forms which grew in the six habitats enabled a variety of faunal groups to exist. The loss of any of these habitats would result in the reduction or elimination of those species utilizing them. If future alterations of the river are made, they should be planned with a specific objective of maintaining areas of all six of these habitats to preserve the diversity of wildlife found there.

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Appendix A. Common and scientific names of plant species referred to in the text (Van Bruggen 1976).

PTERIDOPHYTA

Family Equisetaceae

Horsetail - Equisetum spp. L.

GYMNOSPERMEAE

Family Cupressaceae

Eastern red cedar - Juniperus virginiana L.

ANGIOSPERMEAE

Monocotyledoneae

Family Juncaceae

Rush - Juncus spp.

Family Cyperaceae

Sedge - Carex spp. L.

Family Poaceae

Tribe Agrostideae

Bluejoint - Calamagrostis canadensis (Michx.) Beauv.

Tribe Aveneae

Oat - Avena sativa L.

Tribe Hordeae

Wheat - Triticum aestivum L.

Tribe Paniceae

Foxtail - Setaria spp. Beauv.

Family Typhaceae

Narrow-leaved cattail - Typha angustifolia L.

Family Lemnaceae

Duckweed - Lemna spp.

Family Liliaceae

Greenbriar - Smilax hispida Muhl.

Dicotyledoneae

Family Salicaceae

Eastern cottonwood - Populus deltoides Marsh.

Sandbar willow - Salix exigua interior (Rowlee) Cronquist

Peach-leaved willow - Salix amygdaloides Anderss.  
Diamond willow - Salix rigida Muhl.

Family Juglandaceae

Black walnut - Juglans nigra L.  
Shagbark hickory - Carya ovata<sup>a</sup>

Family Fagaceae

Bur oak - Quercus macrocarpa Michx.

Family Ulmaceae

Slippery elm - Ulmus rubra L.

Family Moraceae

Mulberry - Morus alba L.

Family Menispermaceae

Moonseed - Menispermum canadense L.

Family Saxifragaceae

Gooseberry - Ribes missouriense Nutt.

Family Plantanaceae

Sycamore - Plantanus occidentalis<sup>a</sup>

Family Rosaceae

Wild rose - Rosa woodsii Lindl.  
Black raspberry - Rubus occidentalis L.

Family Fabaceae

Alfalfa - Medicago sativa L.  
False-indigo - Amorpha fruticosa L.  
Honey locust - Gleditsia triacanthos L.  
Kentucky coffeetree - Gymnocladus dioica (L.) Koch

Family Anacardiaceae

Smooth sumac - Rhus glabra L.  
Poison ivy - Toxicodendron rydbergii (Small) Greene

Family Celastraceae

Bittersweet - Celastrus scandens L.

Family Aceraceae

Box elder - Acer negundo L.

Family Vitaceae

Virginia creeper - Parthenocissus quinquefolia (L.) Planch.  
Riverbank grape - Vitis riparia Michx.

## Family Tiliaceae

Basswood - Tilia americana L.

## Family Elaeagnaceae

Russian olive - Elaeagnus angustifolia L.

## Family Cornaceae

Red-osier dogwood - Cornus stolonifera Michx.

## Family Oleaceae

Green ash - Fraxinus pennsylvanica Marsh.

## Family Caprifoliaceae

Tatarian honeysuckle - Lonicera tatarica L.

Wolfberry - Symphoricarpus occidentalis Hook.

<sup>a</sup>These species were referred to by Vaubel and Hoffman (1975) as occurring in Nebraska. Scientific names from Petersen (1912).

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Appendix B. Formulas used in vegetation analyses.

Relative Dominance (Trees) <sup>a</sup>	=	Average basal area over all plots for each tree species within a habitat type	
		$\frac{\text{Total of the average basal areas over all plots for each tree species within a habitat type}}{\text{Total of the average basal areas over all plots for each tree species within a habitat type}}$	X 100
Relative Dominance (Trees) <sup>b</sup>	=	$\frac{\text{Total basal area for each tree species within a sampling site}}{\text{Total basal area for all tree species within a sampling site}}$	X 100
Relative Density (Trees/Shrubs)	=	Average number of trees/shrubs over all plots of each species within a habitat type	
		$\frac{\text{Total average number of trees/shrubs over all plots of each species within a habitat type}}{\text{Total average number of trees/shrubs over all plots of each species within a habitat type}}$	X 100
Relative Frequency (Shrubs)	=	Number of rectangular plots per habitat type in which a species occurred	
		$\frac{\text{Sums of rectangular plots of occurrence per habitat type for all species}}{\text{Sums of rectangular plots of occurrence per habitat type for all species}}$	X 100
Absolute Frequency (Vines)	=	Number of sampling sites per habitat type in which a vine species occurred	
		$\frac{\text{Number of sampling sites per habitat type}}{\text{Number of sampling sites per habitat type}}$	X 100

<sup>a</sup>Calculation used in importance values.

<sup>b</sup>Calculation used in overlap values.

# Appendix C. Application of index of overlap (Horn 1966).

Index of overlap (Horn 1966) was calculated using the following formula:

$$R_o = \frac{(x_i + y_i) \log (x_i + y_i) - x_i \log x_i - y_i \log y_i}{(X + Y) \log (X + Y) - X \log X - Y \log Y} \quad (1)$$

where  $R_o$  = overlap,  $X = Y = 1$ , and the values  $x_i$  and  $y_i$  represent the percentages of each sample site composed of plant species  $i$ . Resulting  $R_o$  values ranged from 0.00 when the two sites had no species in common to 1.00 when the proportional species composition was identical.

Relative dominance of each tree species and relative density of each shrub species was used on a sample site basis (combined plots) for the values of  $x$  and  $y$ . These values were calculated for each sample site and not for each habitat type as used in calculating importance values. All willow species on each site were combined for this analysis because computer analysis did not distinguish between two closely related species such as willows and two totally unrelated species such as willow and red-osier dogwood. Computer analysis resulted in a site overlap index for each of the 21 sites paired with each of the remaining sites.

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#### Appendix D. Results of small mammal trapping.

Four hundred and fourteen small mammals representing six species of mice, shrews, and voles were trapped during 4,273 trap-nights. White-footed mice and deer mice comprised almost 90 percent of the catch, while short-tailed shrews, western harvest mice, meadow voles, and masked shrews were captured less frequently (Table 1).

Deer mice and white-footed mice were captured most frequently in sand dune habitat (Table 2). Deer mice were also the most abundant species in sand dune habitat along the unchannelized Missouri River in North Dakota (Hibbard 1972). Numerous studies have reported that deer mice prefer non-wooded areas such as prairies, open fields, and sand dunes (Beckwith 1954, Verts 1957, Wetzel 1958, Iverson et al. 1967, Kaufman and Fleharty 1974).

White-footed mice were the most frequently captured species in cottonwood-willow habitat, followed by deer mice, western harvest mice, and meadow voles (Table 2). White-footed mice were generally taken at stations near or in willow thickets, while the other three species were captured in open areas. Smith (1968) captured only white-footed mice while studying the home range of this species in cottonwood-willow habitat in southeastern South Dakota. Hibbard (1972) reported deer mice as being most abundant (2.9 captures per 100 trap-nights) in cottonwood-willow habitat in North Dakota, followed by meadow jumping mice and boreal red-backed voles (Clethrionomys gapperi). The range of the boreal red-backed vole does not extend as far south as my



Table 1. Species composition of small mammals captured along the unchannelized Missouri River in South Dakota.

Species	Number Captured	Captures/ 100 TN	Percent
White-footed mouse	304	7.11	73.43
Deer mouse	68	1.59	16.43
Short-tailed shrew	19	0.44	4.59
Western harvest mouse	11	0.26	2.66
Meadow vole	9	0.21	2.17
Masked shrew	3	0.07	0.72
Total	414	9.68	100.00

Table 2. Number and species of small mammals captured per 100 trap-nights, listed by habitat type. These values were calculated using the number of trap-nights in each habitat type.

Species	Habitat Type			
	Sand Dune	Cottonwood-willow	Cottonwood-dogwood	Elm-oak
White-footed mouse	5.73	4.17	11.93	4.95
Deer mouse	10.28	1.39	0.06	0.00
Short-tailed shrew	0.00	0.00	1.17	0.00
Western harvest mouse	0.00	1.02	0.00	0.00
Meadow vole	0.20	0.65	0.06	0.00
Masked shrew	0.00	0.00	0.18	0.00
Total	16.21	7.23	13.40	4.95

study area (Hall and Kelson 1959). Lindell (1971) captured meadow jumping mice in cottonwood-willow habitat within the range of my study area. Because of the variability of the vegetation within cottonwood-willow habitat, representatives of all species present within this habitat were probably not captured.

White-footed mice comprised 89 percent of the total catch in cottonwood-dogwood habitat (11.93 per 100 trap-nights), while other species were caught in lower numbers (Table 2). All but one of 22 short-tailed shrews and masked shrews were captured in sampling sites of Segment 1, which consisted of older cottonwood-dogwood stands. The single meadow vole was captured in a grassy area, and the deer mouse was apparently an accidental visitor. White-footed mice have frequently been reported as the most abundant species on densely wooded floodplains (Wetzel 1958, Ranney 1966, Iverson et al. 1967, Hibbard 1972, Kaufman and Fleharty 1974). Short-tailed shrews occupy habitats having large numbers of invertebrates and soils permitting burrowing (Wetzel 1958). The sampling sites in which most of these shrews were captured were more mature cottonwood stands, where heavy accumulations of leaf litter provided habitat for invertebrates. The younger cottonwood-dogwood sites in Segments 2 and 3 had little leaf litter.

Captures per 100 trap-nights were lowest in the elm-oak habitat (4.95), and only small numbers of white-footed mice were captured (Table 2). Live vegetation was sparse because of grazing and provided little protection or food. The lack of moist leaf litter

made conditions unsuitable for shrews, the other forest dwelling small mammals expected to occur in elm-oak habitat.

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## Appendix E. Bird species diversity and species composition of habitats.

### BIRD SPECIES DIVERSITY

#### The Diversity Index

Although the value of a habitat to an avian community can be reflected by the number of species present within an area, two problems exist in using only species counts: (1) they do not account for differences in species abundance, and (2) they depend on sample size (MacArthur 1965). Information theory, originally developed for use in communications (Shannon and Weaver 1949), has been suggested as a means to combine the number of species and the number of individuals of each species into one figure depicting species diversity (Margalef 1958, MacArthur and MacArthur 1961). When used in ecology, information theory reflects the amount of uncertainty in choosing a random individual of a particular species (Pielou 1966). The diversity index of a community will increase with more species (species richness) or if the total number of individuals is more evenly distributed (equitability) (Lloyd and Ghelardi 1964). The Shannon-Weaver index (Shannon and Weaver 1949) was used to calculate bird species diversity (BSD) using the following formula:

$$H' = - \sum p_i \log_e P_i \quad (1)$$

where  $H'$  is species diversity and  $p_i$  is the proportion of all species belonging to the  $i$ th species.

### Bird Species Diversity in Relation to Succession

Bird species diversity was lowest in sand dune habitat (1.9), increased slightly in cottonwood-willow (2.1) and cottonwood-dogwood (2.2) habitats, then decreased to 2.0 in elm-oak habitat (Table 1). Although the differences in BSD between habitats are not great, a trend existed showing the data in this study to follow the generally accepted increase in BSD as vegetation approaches climax (Margalef 1963, Karr 1968, Kricher 1972). The decrease in BSD recorded in elm-oak habitat may have been caused by a normal decline in species diversity for a climax forest (Margalef 1963), by a reduction in foliage height diversity (MacArthur and MacArthur 1961) caused by grazing, or a combination of both.

### SPECIES COMPOSITION OF HABITATS

#### Method

Importance values for all species in each habitat were calculated to evaluate avian composition. Importance was determined by adding the average relative density per census and the relative frequency (number of censuses in which the species occurred). The maximum importance value each species could attain was 200.

#### Results

Sand Dune.--Northern (Baltimore) orioles (0.92), catbirds (0.86), and eastern kingbirds (0.80) were the most important bird species in sand dune habitat (Table 1). Northern orioles were associated with

Table 1. Importance values of bird species identified in four terrestrial riparian habitats. Species are listed in order of decreasing overall importance.

Species	No. of Habitats	Importance Value by Habitat Type			
		Sand dune	Cottonwood-willow	Cottonwood-dogwood	Elm-oak
Mourning dove	4	0.70	0.73	1.09	0.83
Black-capped chickadee	4	0.62	0.64	0.90	0.83
Northern oriole	4	0.92	0.83	0.79	0.32
Blue jay	4	0.53	0.30	0.97	0.83
Catbird	4	0.86	0.76	0.75	0.15
Eastern kingbird	4	0.80	0.53	0.55	0.32
Common grackle	4	0.70	0.68	0.57	0.22
House wren	4	0.22	0.11	1.15	0.57
Rose-breasted grosbeak	4	0.15	0.33	0.66	0.75
American robin	4	0.47	0.14	0.64	0.41
Brown thrasher	4	0.57	0.47	0.50	0.14
Common flicker	3	0.00	0.51	0.72	0.66
Brown-headed cowbird	3	0.52	0.63	0.22	0.00
Yellowthroat	3	0.47	0.58	0.20	0.00
Hairy woodpecker	3	0.29	0.00	0.33	0.50
White-breasted nuthatch	3	0.15	0.00	0.30	0.67
Red-winged blackbird	3	0.00	0.63	0.10	0.00
Eastern wood peewee	3	0.38	0.00	0.32	0.32
Wood thrush	3	0.42	0.10	0.31	0.00

Table 1. Continued.

Species	No. of Habitats	Importance Value by Habitat Type			
		Sand dune	Cottonwood-willow	Cottonwood-dogwood	Elm-oak
Red-headed woodpecker	3	0.15	0.00	0.20	0.24
Bobwhite quail	3	0.00	0.08	0.22	0.15
Common crow	3	0.15	0.00	0.13	0.09
American goldfinch	2	0.00	0.69	0.00	0.33
Song sparrow	2	0.31	0.59	0.00	0.00
Cardinal	2	0.00	0.00	0.12	0.71
Field sparrow	2	0.00	0.47	0.00	0.32
Rough-winged swallow	2	0.45	0.14	0.00	0.00
Barn swallow	2	0.20	0.37	0.00	0.00
Ring-necked pheasant	2	0.00	0.42	0.12	0.00
Downy woodpecker	2	0.00	0.00	0.18	0.29
Red-bellied woodpecker	2	0.00	0.00	0.11	0.22
Yellow-billed cuckoo	2	0.00	0.09	0.00	0.15
Warbling vireo	2	0.00	0.09	0.19	0.00
Orchard oriole	2	0.00	0.07	0.15	0.00
Yellow-throated vireo	2	0.00	0.07	0.00	0.12
Great horned owl	2	0.00	0.07	0.07	0.00
Lark sparrow	1	0.32	0.00	0.00	0.00
Bank swallow	1	0.00	0.28	0.00	0.00
Eastern meadowlark	1	0.00	0.28	0.00	0.00



Table 1. Continued.

Species	No. of Habitats	Importance Value by Habitat Type			
		Sand dune	Cottonwood-willow	Cottonwood-dogwood	Elm-oak
Killdeer	1	0.00	0.27	0.00	0.00
Great-crested flycatcher	1	0.00	0.00	0.00	0.27
Ruby-throated hummingbird	1	0.00	0.00	0.00	0.27
Wood duck	1	0.00	0.25	0.00	0.00
Yellow-headed blackbird	1	0.00	0.22	0.00	0.00
Whip-poor-will	1	0.00	0.00	0.00	0.16
Mockingbird	1	0.00	0.00	0.15	0.00
Rufous-sided towhee	1	0.00	0.00	0.00	0.14
Spotted sandpiper	1	0.00	0.12	0.00	0.00
Starling	1	0.00	0.00	0.11	0.00
Yellow-crowned night heron	1	0.00	0.10	0.00	0.00
Marsh sparrow	1	0.00	0.09	0.00	0.00
Prothonotary warbler	1	0.00	0.00	0.09	0.00
Cliff swallow	1	0.00	0.08	0.00	0.00
Kingfisher	1	0.00	0.00	0.07	0.00
Broad-winged hawk	1	0.00	0.00	0.00	0.05
Turkey vulture	1	0.00	0.00	0.00	0.05
Wild turkey	1	0.00	0.00	0.00	0.05
Total Species Recorded		23	37	34	32
Bird Species Diversity		1.93	2.09	2.19	2.04

taller cottonwoods, while catbirds and kingbirds were usually observed in dense thickets of willows and sapling cottonwoods. The northern oriole, which showed the highest importance value (0.92) in sand dune habitat, was not reported by Hibbard (1972) along the Missouri River in North Dakota. The catbird and kingbird, however, were recorded in both sites, as were several other species: yellowthroat, song sparrow, brown-headed cowbird, American robin, mourning dove, house wren, and black-capped chickadee.

Cottonwood-willow.--The northern oriole had the highest importance value (0.83) in cottonwood-willow habitat and was associated with tall cottonwoods. Mourning doves occurred frequently, probably using the area for nesting. Other important bird species using this habitat were the catbird, American goldfinch, common grackle, black-capped chickadee, and brown-headed cowbird. Catbirds, goldfinches, and chickadees nested or fed in shrubs and have been previously recorded utilizing willow thickets along streams (Beecher 1942, Beidleman 1947). Bank swallows, barn swallows, rough-winged swallows, and cliff swallows fed on insects above moist, open areas. Ponds in cottonwood-willow habitat provided brooding areas for blue-winged teal and wood ducks, and feeding areas for herons. The pond shorelines provided feeding areas for shorebirds; killdeer and spotted sandpipers were recorded. Eastern meadowlarks found nesting cover in the taller herbaceous or grassy growth. Although the density of each bird species was not high, cottonwood-willow habitat provided nesting and feeding locations for 37 species, more than in any other habitat.

Cottonwood-dogwood.--Thirty-four species were recorded in cottonwood-dogwood habitat. Mourning doves (1.09) and house wrens (1.15) had the highest importance values, because both species were very common in this habitat. Mourning doves occurred in 22 of the 23 censuses, while house wrens occurred in all 23. House wrens were the second most abundant species in a Montana cottonwood community (Walcheck 1970) behind yellow warblers, which were not recorded in this study. Other important species found in both studies included the black-capped chickadee, northern oriole, catbird, common (yellow-shafted) flicker, and American robin. Rose-breasted grosbeaks and blue jays were not found in cottonwood forests in Montana (Walcheck 1970) or North Dakota (Hibbard 1972), but were present in Kansas (Zimmerman and Tatschl 1975) and this study. These records indicate that the study area represents the westernmost limits of rose-breasted grosbeaks and blue jays in cottonwood communities along the free-flowing portions of the Missouri River.

Elm-oak.--Mourning doves (0.83), black-capped chickadees (0.83), and blue jays (0.83) had the highest importance values in elm-oak habitat. Anderson and Shugart (1974) found that blue jays were generally associated with large trees providing a dense overstory, and I found that blue jays obtained their highest importance values in the two habitats with taller, older trees (cottonwood-dogwood and elm-oak). Rose-breasted grosbeaks (0.75) and cardinals (0.71) also had high importance values in elm-oak habitat. The importance value of the cardinal is somewhat difficult to explain. This species is

generally considered to be a shrub dweller (Anderson and Shugart 1974), but few shrubs were present in elm-oak habitat. Two other shrub nesters, the brown thrasher and the gray catbird, were common in the cottonwood habitats but were absent or had a much lower importance value in elm-oak habitat. Their absence is probably caused by livestock grazing, which reduced the number of suitable nesting sites.

White-breasted nuthatches, hairy woodpeckers, downy woodpeckers, and red-bellied woodpeckers were cavity nesters having higher importance values in the grazed elm-oak habitat than in the ungrazed cottonwood communities, and great crested flycatchers (also a cavity nester) were observed only in the elm-oak habitat. The increase in cavity nesting resulted from an increase in the number of cavities in dying trees. The increase in the number of cavity nesters may also have been related to grazing. Dambach and Good (1940) stated that nesting birds were affected in three ways by grazing: (1) no ground nesters were found, (2) there was a 20 percent increase in the number of hole nesters, and (3) only one nest was located in shrubby vegetation. Bobwhite quail, the only ground nester recorded in elm-oak habitat, had a low importance value (0.15) and the occurrence of the other two factors is clearly illustrated. Without grazing, the avian populations of this habitat would probably have been larger and more diverse.

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Appendix F. Mammalian species expected to occur in the study area (Hall and Kelson 1959).

## Order Marsupialia

### Family Didelphidae

Opossum - Didelphis marsupialis virginia Kerr

## Order Insectivora

### Family Soricidae

Masked shrew - Sorex cinereus haydeni Baird

Short-tailed shrew - Blarina brevicauda brevicauda (Say)

Least shrew - Cryptotis parva parva (Say)

Pygmy shrew - Microsorex hoyi hoyi (Baird)

### Family Talpidae

Eastern mole - Scalopus aquaticus caryi Jackson

Eastern mole - Scalopus aquaticus machrinoides Jackson

## Order Chiroptera

### Family Vespertilionidae

Little brown myotis - Myotis lucifugus lucifugus (Le Conte)

Keen's myotis - Myotis keeni septentrionalis (Trouessart)

Small-footed myotis - Myotis subulatus subulatus (Say)

Silver-haired bat - Lasiorycteris noctivagans (Le Conte)

Big brown bat - Eptesicus fuscus fuscus (Palisot de Beauvois)

Red bat - Lasiurus borealis borealis (Müller)

Hoary bat - Lasiurus cinereus cinereus (Palisot de Beauvois)

## Order Lagomorpha

### Family Leporidae

Eastern cottontail - Sylvilagus floridanus mearnsii (J. A. Allen)

Eastern cottontail - Sylvilagus floridanus similis Nelson

White-tailed jackrabbit - Lepus townsendii campanius Hollister

Black-tailed jackrabbit - Lepus californicus melanotis Mearns

## Order Rodentia

### Family Sciuridae

Woodchuck - Marmota monax bunkerii Black

Thirteen-lined ground squirrel - Spermophilus tridecemlineatus tridecemlineatus (Mitchill)

Franklin's ground squirrel - Spermophilus franklinii (Sabine)  
 Eastern gray squirrel - Sciurus carolinensis carolinensis Gmelin  
 Fox squirrel - Sciurus niger rufiventer E. Geoffrey St.-Hilaire

Family Geomyidae

Plains pocket gopher - Geomys bursarius majusculus Swenk

Family Heteromyidae

Plains pocket mouse - Perognathus flavescens perniger Osgood

Family Castoridae

Beaver - Castor canadensis missouriensis V. Bailey

Family Cricetidae

Plains harvest mouse - Reithrodontomys montanus albescens Cary  
 Western harvest mouse - Reithrodontomys megalotis dychei J. A. Allen  
 Deer mouse - Peromyscus maniculatus bairdii (Hoy and Kennicott)  
 White-footed mouse - Peromyscus leucopus noveboracensis (Fischer)  
 Meadow vole - Microtus pennsylvanicus pennsylvanicus (Ord)  
 Prairie vole - Microtus ochrogaster ochrogaster (Wagner)  
 Muskrat - Ondatra zibethicus cinnamominus (Hollister)  
 Southern bog Lemming - Synaptomys cooperii gossii (Coues)

Family Zapodidae

Meadow jumping mouse - Zapus hudsonius pallidus Cockrum and Baker

Order Hystricomorpha

Family Erethizontidae

Porcupine - Erethizon dorsatum bruneri Swenk  
 Porcupine - Erethizon dorsatum dorsatum (Linnaeus)

Order Carnivora

Family Canidae

Coyote - Canis latrans latrans Say  
 Red fox - Vulpes fulva regalis Merriam  
 Gray fox - Urocyon cinereoargenteus ocythous Bangs

Family Procyonidae

Raccoon - Procyon lotor hirtus Nelson and Goldman

Family Mustelidae

Least weasel - Mustela rixosa campestris Jackson  
 Long-tailed weasel - Mustela frenata spadix (Bangs)  
 Mink - Mustela vison letifera Hollister  
 Badger - Taxidea taxus taxus (Schreber)



Eastern spotted skunk - Spilogale putorius interrupta (Rafinesque)  
 Striped skunk - Mephitis mephitis hudsonica Richardson  
 River otter - Lutra canadensis interior Swenk

Family Felidae

Bobcat - Lynx rufus rufus (Schreber)

Order Artiodactyla

Family Cervidae

White-tailed deer - Odocoileus virginianus virginianus Rafinesque<sup>a</sup>

Mule deer - Odocoileus hemionus hemionus Rafinesque<sup>a</sup>

<sup>a</sup>Opinion 581 of the International Commission on Zoological Nomenclature (1960, cited by Jones 1964) validated Odocoileus Rafinesque as generic name over Dama used by Hall and Kelson (1959).

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Appendix G. Bird species occurring in southeastern South Dakota (Anonymous 1956). Scientific and common names are taken from American Ornithologist's Union (1957) checklist, and its thirty-second (1973) and thirty-third (1976) supplements.

#### Order Gaviiformes

##### Family Gaviidae

Common loon - Gavia immer (Brünnich) (TV)<sup>a</sup>

#### Order Podicipediformes

##### Family Podicipedidae

Red-necked grebe - Podiceps grisegena holbollii Reinhardt (TV)

Horned grebe - Podiceps auritus cornutus (Gmelin) (TV)

Eared grebe - Podiceps nigricollis californicus Heerman (SR)

Western grebe - Aechmophorus occidentalis (Lawrence) (TV)

Pied-billed grebe - Podilymbus podiceps podiceps (Linnaeus) (SR)

#### Order Pelicaniformes

##### Family Pelicanidae

White pelican - Pelecanus erythrorhynchos Gmelin (TV)

##### Family Phalacrocoracidae

Double-crested cormorant - Phalacrocorax auritus auritus (Lesson) (SR)

#### Order Ciconiiformes

##### Family Ardeidae

###### Subfamily Ardeinae

Great blue heron - Ardea herodias herodias Linnaeus (SV)

Northern green heron - Butorides striatus virescens (Linnaeus) (SR)

Little blue heron - Florida caerulea caerulea (Linnaeus) (TV)

Great egret - Casmerodius albus egretta (Gmelin) (SV)

Black-crowned night heron - Nycticorax nycticorax hoactli (Gmelin) (SR)

###### Subfamily Botaurinae

Least bittern - Ixobrychus exilis exilis (Gmelin) (SR)

American bittern - Botaurus lentiginosus (Rackett) (SR)

## Order Anseriformes

## Family Anatidae

## Subfamily Cygninae

Whistling swan - Olor columbianus (Ord) (TV)

## Subfamily Anserinae

Canada goose - Branta canadensis (Linnaeus) (TV)

White-fronted goose - Anser albifrons frontalis Baird (TV)

Snow goose - Chen caerulescens (Pallas) (TV)

Blue goose - Chen caerulescens atlantica (Linnaeus) (TV)

## Subfamily Anatinae

Mallard - Anas platyrhynchos platyrhynchos Linnaeus (SR)

Black duck - Anas rubripes Brewster (AV)

Gadwall - Anas strepera Linnaeus (SR)

Pintail - Anas acuta Linnaeus (SR)

American green-winged teal - Anas crecca carolinensis Gmelin (TV)

Blue-winged teal - Anas discors discors Linnaeus (SR)

Cinnamon teal - Anas cyanoptera septentrionalium Snyder and Lumsden (AV)

American wigeon - Anas americana (Gmelin) (SR)

Northern shoveler - Anas clypeata (Linnaeus) (SR)

Wood duck - Aix sponsa (Linnaeus) (SR)

## Subfamily Aythyinae

Redhead - Aythya americana (Eyton) (SR)

Ring-necked duck - Aythya collaris (Donovan) (TV)

Canvasback - Aythya valisineria (Wilson) (TV)

Greater scaup - Aythya marila nearctica Stejneger (TV)

Lesser scaup - Aythya affinis (Eyton) (TV)

Common goldeneye - Bucephala clangula americana (Bonaparte) (TV)

Bufflehead - Bucephala albeola (Linnaeus) (TV)

Oldsquaw - Clangula hyemalis (Linnaeus) (AV)

Ruddy duck - Oxyura jamaicensis rubida (Wilson) (SR)

Hooded merganser - Lophodytes cucullatus (Linnaeus) (TV)

Common merganser - Mergus merganser americanus Cassin (TV)

Red-breasted merganser - Mergus serrator serrator Linnaeus (TV)

## Order Falconiformes

## Family Cathartidae

Turkey vulture - Cathartes aura teter Friedmann (SV)

## Family Accipitridae

## Subfamily Accipitrinae

Goshawk - Accipiter gentilis atricapillus (Wilson) (WV)

Sharp-shinned hawk - Accipiter striatus velox (Wilson) (PR)

Cooper's hawk - Accipiter cooperii (Bonaparte) (PR)

#### Subfamily Buteoninae

Red-tailed hawk - Buteo jamaicensis kriderii Hoopes (SR)

Red-shouldered hawk - Buteo lineatus lineatus (Gmelin) (TV)

Broad-winged hawk - Buteo platypterus platypterus (Viellot) (TV)

Swainson's hawk - Buteo swainsoni Bonaparte (SR)

Rough-legged hawk - Buteo lagopus s.johannis (Gmelin) (WV)

Ferruginous hawk - Buteo regalis (Gray) (WV)

Golden eagle - Aquila chrysaetos canadensis (Linnaeus) (WV)

Bald eagle - Haliaeetus leucocephalus leucocephalus (Linnaeus) (WV)

#### Subfamily Circinae

Marsh hawk - Circus cyaneus hudsonius (Linnaeus) (PD)

#### Family Panionidae

Osprey - Pandion haliaetus carolinensis (Gmelin) (TV)

#### Family Falconidae

##### Subfamily Falconinae

Gyr Falcon - Falco rusticolus obsoletus Gmelin (AV)

Prairie falcon - Falco mexicanus Schlegel (WV)

Peregrine falcon - Falco peregrinus anatum Bonaparte (TV)

Merlin - Falco columbarius columbarius Linnaeus (TV)

Kestrel - Falco sparverius sparverius Linnaeus (SR)

#### Order Galliformes

##### Family Tetraonidae

Greater prairie chicken - Tympanuchus cupido pinnatus (Brewster) (AV)

Sharp-tailed grouse - Pediocetes phasianellus campestris Ridgway (AV)

##### Family Phasianidae

##### Subfamily Odontophorinae

Bobwhite - Colinus virginianus virginianus (Linnaeus) (PR)

##### Subfamily Phasianinae

Ring-necked pheasant - Phasianus colchicus Linnaeus (PR)

Gray partridge - Perdix perdix perdix (Linnaeus) (PR)

##### Family Meleagrididae

Turkey - Meleagris gallopavo silvestris Viellot (PR)

## Order Gruiformes

## Family Rallidae

## Subfamily Rallinae

King rail - Rallus elegans elegans Audubon (SR)Virginia rail - Rallus limicola limicola Viellot (SR)Sora - Porzana carolina (Linnaeus) (PR)Yellow rail - Coturnicops noveboracensis noveboracensis (Gmelin) (SR)Common gallinule - Gallinula chloropus cachinnans Bangs (AV)

## Subfamily Fulicinae

American coot - Fulica americana americana Gmelin (SR)

## Order Charadriiformes

## Family Charadriidae

Semipalmated plover - Charadrius semipalmatus Bonaparte (TV)Piping plover - Charadrius melodus circumcinctus (Ridgway) (TV)Killdeer - Charadrius vociferus vociferus Linnaeus (SR)American golden plover - Pluvialis dominica dominica (Müller) (TV)Black-bellied plover - Squatarola squatarola (Linnaeus) (TV)Ruddy turnstone - Arenaria interpres morinella (Linnaeus) (TV)

## Family Scolopacidae

## Subfamily Scolopacinae

Common snipe - Capella gallinago delicata (Ord) (TV)

## Subfamily Tringinae

Upland sandpiper - Bartramia longicauda (Bechstein) (SR)Spotted sandpiper - Actitis macularia (Linnaeus) (SR)Solitary sandpiper - Tringa solitaria solitaria Wilson (TV)Willet - Catoptrophus semipalmatus inornatus (Brewster) (TV)Greater yellowlegs - Tringa melanoleucos (Gmelin) (TV)Lesser yellowlegs - Tringa flavipes (Gmelin) (TV)

## Subfamily Calidridiinae

Pectoral sandpiper - Calidris melanotos (Viellot) (TV)White-rumped sandpiper - Calidris fuscicollis (Viellot) (TV)Baird's sandpiper - Calidris bairdii (Coues) (TV)Least sandpiper - Calidris minutilla (Viellot) (TV)Dunlin - Calidris alpina pacifica (Coues) (TV)Semipalmated sandpiper - Calidris pusilla (Linnaeus) (TV)Western sandpiper - Calidris mauri Cabanis (TV)Sanderling - Caladris alba (Pallas) (TV)Short-billed dowitcher - Limnodromus griseus hendersoni Rowan (TV)Long-billed dowitcher - Limnodromus scolopaceus Say (TV)Stilt sandpiper - Micropalama himantopus (Bonaparte) (TV)

- Buff-breasted sandpiper - Tryngites subruficollis (Viellot) (TV)  
 Marbled godwit - Limosa fedoa (Linnaeus) (TV)  
 Hudsonian godwit - Limosa haemastica (Linnaeus) (TV)

Family Recurvirostridae

- American avocet - Recurvirostra americana Gmelin (TV)

Family Phalaropodidae

- Wilson's phalarope - Steganopus tricolor Viellot (TV)  
 Northern phalarope - Lobipes lobatus (Linnaeus) (AV)

Family Laridae

Subfamily Larinae

- Herring gull - Larus argentatus smithsonianus Coues (SV)  
 Ring-billed gull - Larus delawarensis Ord (SV)  
 Franklin's gull - Larus pipixcan Wagler (SR)

Subfamily Sterninae

- Forster's tern - Sterna forsteri Nuttall (SR)  
 Common tern - Sterna hirundo hirundo Linnaeus (SR)  
 Least tern - Sterna albifrons athalassos Burleigh and Lowery (SR)  
 Caspian tern - Hydroprogne caspia (Pallas) (AV)  
 Black tern - Chlidonias niger surinamensis (Gmelin) (SR)

Order Columbiformes

Family Columbidae

- Mourning dove - Zenaida macroura carolinensis (Linnaeus) (SR)

Order Cuculiformes

Family Cuculidae

- Yellow-billed cuckoo - Coccyzus americanus americanus (Linnaeus) (SR)  
 Black-billed cuckoo - Coccyzus erythrophthalmus (Wilson) (SR)

Order Strigiformes

Family Tytonidae

- Barn owl - Tyto alba pratincola (Bonaparte) (PR)

Family Strigidae

- Screech owl - Otus asio swenki Oberholser (PR)  
 Great horned owl - Bubo virginianus virginianus (Gmelin) (PR)  
 Snowy owl - Nyctea scandiaca (Linnaeus) (WV)  
 Burrowing owl - Athene cunicularia hypugaea (Bonaparte) (SR)

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Barred owl - Strix varia varia Barton (PR)  
Long-eared owl - Asio otus wilsonianus (Lesson) (WV)  
Short-eared owl - Asio flammeus flammeus (Pontoppidan) (PR)

Order Caprimulgiformes

Family Caprimulgidae

Whip-poor-will - Caprimulgus vociferus vociferus Wilson (SR)  
Common nighthawk - Chordeiles minor minor (Forster) (SR)

Order Apodiformes

Family Apodidae

Chimney swift - Chaetura pelagica (Linnaeus) (SR)

Family Trochilidae

Ruby-throated hummingbird - Archilochus colubris (Linnaeus) (SR)

Order Coraciiformes

Family Alcedinidae

Belted kingfisher - Megaceryle alcyon alcyon (Linnaeus) (PR)

Order Piciformes

Family Picidae

Yellow-shafted flicker - Colaptes auratus auratus Bangs (PR)  
Red-bellied woodpecker - Melanerpes carolinus zebra (Boddaert) (PR)  
Red-headed woodpecker - Melanerpes erythrocephalus erythrocephalus (Linnaeus) (PR)  
Lewis' woodpecker - Merlanerpes lewis (Gray) (AV)  
Yellow-bellied sapsucker - Sphyrapicus varius varius (Linnaeus) (TV)  
Hairy woodpecker - Picoides villosus villosus (Linnaeus) (FI)  
Downy woodpecker - Picoides pubescens medianus (Swainson) (PR)

Order Passeriformes

Family Tyrannidae

Eastern kingbird - Tyrannus tyrannus (Linnaeus) (SR)  
Western kingbird - Tyrannus verticalis Say (SR)  
Great crested flycatcher - Myiarchus crinitus boreus Bangs (PR)  
Eastern phoebe - Sayornis phoebe (Latham) (SR)  
Say's phoebe - Sayornis saya (Bonaparte) (AV)  
Yellow-bellied flycatcher - Empidonax flaviventris (Baird and Baird) (TV)

Acadian flycatcher - Empidonax virescens (Viellot) (SR)  
 Willow flycatcher - Empidonax traillii (Audubon) (SR)  
 Least flycatcher - Empidonax minimus (Baird and Baird) (TV)  
 Eastern wood peewee - Contopus virens (Linnaeus) (SR)  
 Olive-sided flycatcher - Nuttallornis borealis (Swainson) (TV)

#### Family Alaudidae

Horned lark - Eremophila alpestris praticola (Henshaw) (PR)

#### Family Hirundinidae

Tree swallow - Irotoprocne bicolor (Viellot) (SR)  
 Bank swallow - Riparia riparia riparia (Linnaeus) (SR)  
 Rough-winged swallow - Stelgidopteryx ruficollis serripennis (Audubon) (SR)  
 Barn swallow - Hirundo rustica erythrogaster Boddaert (SR)  
 Cliff swallow - Petrochelidon pyrrhonota pyrrhonota (Viellot) (SR)  
 Purple martin - Progne subis subis (Linnaeus) (SR)

#### Family Corvidae

Blue jay - Cyanocitta cristata bromia Oberholser (PR)  
 Black-billed magpie - Pica pica hudsonia (Sabine) (WV)  
 Common crow - Corvus brachyrhynchos brachyrhynchos Brehm (PR)

#### Family Paridae

Black-capped chickadee - Parus atricapillus atricapillus Linnaeus (PR)

#### Family Sittidae

White-breasted nuthatch - Sitta carolinensis cookei Oberholser (PR)  
 Red-breasted nuthatch - Sitta canadensis Linnaeus (WV)

#### Family Certhiidae

Brown creeper - Certhia familiaris americana Bonaparte (WV)

#### Family Troglodytidae

House wren - Troglodytes aedon parkmanii Audobon (SR)  
 Winter wren - Troglodytes troglodytes hiemalis Viellot (TV)  
 Carolina wren - Thryothorus ludovicianus ludovicianus (Latham) (TV, WV)  
 Long-billed marsh wren - Cistothorus palustris dissaepatus (Bangs) (SR)  
 Short-billed marsh wren - Cistothorus platensis stellaris (Latham) (SR)  
 Rock wren - Salpinctes obsoletus obsoletus (Say) (SR)

#### Family Mimidae

Mockingbird - Mimus polyglottos polyglottos (Linnaeus) (SR)  
 Catbird - Pumetella carolinensis (Linnaeus) (SR)  
 Brown thrasher - Toxostoma rufum rufum (Linnaeus) (SR)

#### Family Turdidae

American robin - Turdus migratorius migratorius Linnaeus (SR)  
 Wood thrush - Hylocichla mustelina (Gmelin) (SR)



Hermit thrush - Carathus guttatus faxoni Bangs and Benard (TV)  
 Swainson's thrush - Carathus ustulatus swainsoni (Tschudi) (TV)  
 Gray-cheeked thrush - Carathus minimus minimus (Lafresnaye) (TV)  
 Veery - Carathus fuscescens fuscescens (Stephens) (TV)  
 Common bluebird - Sialia sialis sialis (Linnaeus) (SR)

Family Sylviidae

Golden-crowned kinglet - Regulus satrapa satrapa Lichtenstein (TV, WV)  
 Ruby-crowned kinglet - Regulus calendula calendula (Linnaeus) (TV)

Family Motacillidae

Water pipit - Anthus spinoletta rubescens (Tunstall) (TV)  
 Sprague's pipit - Anthus spragueii (Audubon) (TV)

Family Bombycillidae

Bohemian waxwing - Bombycilla garrulus pallidiceps Reichenow (WV)  
 Cedar waxwing - Bombycilla cedrorum Vieillot (PR)

Family Laniidae

Northern shrike - Lanius excubitor invictus Grinnell (WV)  
 Loggerhead shrike - Lanius ludovicianus migrans Palmer (SR)

Family Sturnidae

Starling - Sturnus vulgaris vulgaris Linnaeus (PR)

Family Vireonidae

Bell's vireo - Vireo bellii bellii Audubon (SR)  
 Yellow-throated vireo - Vireo flavifrons Vieillot (SP)  
 Solitary vireo - Vireo solitarius solitarius (Wilson) (TV)  
 Red-eyed vireo - Vireo olivaceus (Linnaeus) (SR)  
 Philadelphia vireo - Vireo philadelphicus (Cassin) (TV)  
 Warbling vireo - Vireo gilvus gilvus (Vieillot) (SR)

Family Parulidae

Black-and-white warbler - Mniotilta varia (Linnaeus) (TV)  
 Prothonotary warbler - Protonotaria citrea (Boddaert) (SR)  
 Blue-winged warbler - Vermivora pinus (Linnaeus) (AV)  
 Golden-winged warbler - Vermivora chrysoptera (Linnaeus) (TV)  
 Tennessee warbler - Vermivora peregrina (Wilson) (TV)  
 Orange-crowned warbler - Vermivora celata celata (Say) (TV)  
 Nashville warbler - Vermivora ruficapilla ruficapilla (Wilson) (TV)  
 Parula warbler - Parula americana (Linnaeus) (TV)  
 Yellow warbler - Dendroica petechia aestiva (Gmelin) (SR)  
 Magnolia warbler - Dendroica magnolia (Wilson) (TV)  
 Cape May warbler - Dendroica tigrina (Gmelin) (TV)  
 Myrtle warbler - Dendroica coronata coronata (Linnaeus) (TV)  
 Black-throated green warbler - Dendroica virens virens (Gmelin) (TV)  
 Cerulean warbler - Dendroica cerulea (Wilson) (TV)  
 Blackburnian warbler - Dendroica fusca (Müller) (TV)

Chestnut-sided warbler - Dendroica pensylvanica (Linnaeus) (TV)  
 Bay-breasted warbler - Dendroica castanea (Wilson) (TV)  
 Blackpoll warbler - Dendroica striata (Forster) (TV)  
 Pine warbler - Dendroica pinus pinus (Wilson) (TV)  
 Palm warbler - Dendroica palmarum palmarum (Gmelin) (TV)  
 Ovenbird - Seiurus aurocapillus aurocapillus (Linnaeus) (SR)  
 Northern waterthrush - Seiurus noveboracensis notabilis Ridgway (TV)  
 Louisiana waterthrush - Seiurus motacilla (Viellot) (TV)  
 Connecticut warbler - Oporornis agilis (Wilson) (TV)  
 Mourning warbler - Oporornis philadelphia (Wilson) (TV)  
 Yellowthroat - Geothlypis trichas brachidactylus (Swainson) (SR)  
 Yellow-breasted chat - Icteria virens virens (Linnaeus) (SR)  
 Wilson's warbler - Wilsonia pusilla pileolata (Pallas) (TV)  
 Canada warbler - Wilsonia canadensis (Linnaeus) (TV)  
 American redstart - Setophaga ruticilla ruticilla (Linnaeus) (TV)

#### Family Ploceidae

House sparrow - Passer domesticus domesticus (Linnaeus) (PR)

#### Family Icteridae

Bobolink - Dolichonyx oryzivorus (Linnaeus) (SR)  
 Eastern meadowlark - Sturnella magna magna (Linnaeus) (SR)  
 Yellow-headed blackbird - Xanthocephalus xanthocephalus (Bonaparte) (SR)  
 Red-winged blackbird - Agelaius phoeniceus arctolegus Oberholser (SR)  
 Orchard oriole - Icterus spurius (Linnaeus) (SR)  
 Baltimore oriole - Icterus galbula galbula (Linnaeus) (SR)  
 Rusty blackbird - Euphagus carolinus carolinus (Müller) (TV)  
 Brewer's blackbird - Euphagus cyanocephalus (Wagler) (TV)  
 Common grackle - Quiscalus quiscula versicolor Viellot (SR)  
 Brown-headed cowbird - Molothrus ater ater (Boddaert) (SR)

#### Family Thraupidae

Scarlet tanager - Piranga olivacea (Gmelin) (SR)

#### Family Fringillidae

##### Subfamily Cardinalinae

Cardinal - Cardinalis cardinalis cardinalis (Linnaeus) (PR)  
 Rose-breasted grosbeak - Pheucticus ludovicianus (Linnaeus) (SR)  
 Black-headed grosbeak - Pheucticus melanocephalus melanocephalus (Swainson) (SR)  
 Blue grosbeak - Guiraca caerulea interfusa Dwight and Griscom (SR)  
 Indigo bunting - Passerina cyanea (Linnaeus) (SR)  
 Lazuli bunting - Passerina amoena (Say) (AV)  
 Dickcissel - Spiza americana (Gmelin) (SR)

##### Subfamily Fringillinae

Evening grosbeak - Hesperiphona vespertina vespertina (Cooper) (WV)  
 Purple finch - Carpodacus purpureus purpureus (Gmelin) (WV)

Pine grosbeak - Pinicola enucleator leucura (Müller) (AV)  
 Common redpoll - Carduelis flammea flammea (Linnaeus) (WV)  
 Pine siskin - Carduelis pinus pinus (Wilson) (PR)  
 American goldfinch - Carduelis tristis tristis (Linnaeus) (PR)  
 Red crossbill - Loxia curvirostra benti Griscom (WV)  
 White-winged crossbill - Loxia leucoptera leucoptera Gmelin (WV)  
 Rufous-sided towhee (Eastern race) - Pipilo erythrophthalmus erythrophthalmus (Linnaeus) (SR)  
 Rufous-sided towhee (Western race) - Pipilo erythrophthalmus arcticus (Swainson) (SR)  
 Lark bunting - Calamospiza melanocorys Stejneger (SR)  
 Savannah sparrow - Passerculus sandwichensis nevadensis Grinnell (SR)  
 Baird's sparrow - Ammodramus bairdii (Audubon) (AV)  
 LeConte's sparrow - Ammodramus leconteii (Audubon) (TV)  
 Vesper sparrow - Pooecetes gramineus gramineus (Gmelin) (SR)  
 Lark sparrow - Chondestes grammacus grammacus (Say) (SR)  
 Slate-colored junco - Junco hyemalis hyemalis (Linnaeus) (WV)  
 Tree sparrow - Spizella arborea arborea (Wilson) (WV)  
 Chipping sparrow - Spizella passerina boreophila Oberholser (SR)  
 Clay-colored sparrow - Spizella pallida (Swainson) (SR)  
 Field sparrow - Spizella pusilla pusilla (Wilson) (SR)  
 Harris' sparrow - Zonotrichia querula (Nuttall) (TV, WV)  
 White-crowned sparrow - Zonotrichia leucophrys leucophrys (Forster) (TV, WV)  
 Fox sparrow - Passerilla iliaca zaboria Oberholser (TV)  
 Lincoln's sparrow - Melospiza lincolni lincolni (Audubon) (TV)  
 Swamp sparrow - Melospiza georgiana georgiana (Latham) (SR)  
 Song sparrow - Melospiza melodia juddi Bishop (SR)  
 Lapland longspur - Calcarius lapponicus lapponicus (Linnaeus) (WV)  
 Smith's longspur - Calcarius pictus (Swainson) (TV)  
 Chestnut-collared longspur - Calcarius ornatus (Townsend) (WV)  
 Snow bunting - Plectrophenax nivalis nivalis (Linnaeus) (WV)

<sup>a</sup>TV = Transient visitor, SR = Summer resident, WR = Winter resident,  
 PR = Permanent resident

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Appendix H. Amphibians and reptiles expected to occur in the study area (Fishbeck and Underhill 1959).

# Order Caudata

## Family Ambystomatidae

- Eastern tiger salamander - Ambystoma tigrinum melanosticum (Green)
- Eastern tiger salamander - Ambystoma tigrinum tigrinum (Green)

# Order Anura

## Family Pelobatidae

- Central plains spadefoot - Scaphiopus bombifrons Cope

## Family Bufonidae

- Great plains toad - Bufo cognatus Say
- American toad - Bufo terrestris americanus Girard
- Woodhouse's toad - Bufo woodhousei woodhousei Girard

## Family Hylidae

- Southern cricket frog - Acris gryllus Le Conte
- Common tree frog - Hyla versicolor Le Conte
- Swamp tree frog - Pseudacris triseriata triseriata x maculata (Le Conte)

## Family Ranidae

- Bullfrog - Rana catesbeiana Shaw
- Meadow frog - Rana pipiens Schreber

# Order Testudines

## Family Chelydridae

- Snapping turtle - Chelydra serpentina Linnaeus

## Family Emydidae

- False map turtle - Graptemys pseudogeographica pseudogeographica Gray
- Western painted turtle - Chrysemys picta belli Gray

## Family Trionychidae

- Le Sueur's soft-shelled turtle - Trionyx muticus Le Sueur
- Western soft-shelled turtle - Trionyx ferox hartwegi Conant and Goin

## Order Squamata

## Suborder Lacertilia

## Family Skinkidae

Five-lined skink - Eumeces fasciatus Linnaeus

Northern prairie skink - Eumeces septentrionalis septentrionalis  
Baird

## Suborder Serpentes

## Family Colubridae

Western plains garter snake - Thamnophis radix haydeni Kennicott

Red-sided garter snake - Thamnophis sirtalis parietalis Say

Lined snake - Tropidoclonion lineatum Hallowell

Eastern hognose snake - Heterodon platyrhinos platyrhinos Latreille

Western hognose snake - Heterodon nasicus nasicus Baird and Girard

Prairie ringneck snake - Diadophis punctatus arnyi Kennicott

Yellow-bellied racer - Coluber constrictor flaviventris Say

Western smooth green snake - Opheodrys vernalis blanchardi Grobman

Western fox snake - Elaphe vulpina vulpina Baird and Girard

Bullsnake - Pituophis catenifer sayi Schlegel

Pale milk snake - Lampropeltis dolia multistrata Kennicott

## Family Viperidae

Prairie rattlesnake - Crotalus viridis viridis Rafinesque

## LITERATURE CITED

- Fishbeck, D. W., and J. C. Underhill. 1959. A checklist of the amphibians and reptiles of South Dakota. Proc. South Dakota Acad. Sci. 30:107-113.

Appendix I. Average values for each habitat to nine faunal groups by segment.

Table 1. Wildlife habitat values for cattail marsh habitat.

Faunal Group	Segment			Interspersion Value	Average
	I	II	III		
Big Game	3.5	No Site	No Site	1.1	4.6
Upland Game Mammals	NA				NA
Furbearers	8.5			1.1	9.6
Small Mammals	NA				NA
Upland Game Birds	NA				NA
Waterfowl	8.0			1.1	9.1
Other Water and Marsh Birds	8.0			1.1	9.1
Terrestrial Birds	NA				NA
Reptiles and Amphibians	8.5			1.1	9.6

Table 2. Wildlife habitat values for cottonwood-dogwood habitat.

Faunal Group	Segment			Interspersion Value	Average
	I	II	III		
Big Game	8.0	7.7	8.5	0.9	9.0
Upland Game Mammals	8.5	6.0	7.5	0.9	8.2
Furbearers	7.7	6.7	7.0	0.9	8.0
Small Mammals	8.2	7.2	6.5	0.9	8.2
Upland Game Birds	7.5	7.3	7.5	0.9	8.3
Waterfowl	NA	NA	NA		NA
Other Water and Marsh Birds	NA	NA	NA		NA
Terrestrial Birds	8.2 <sup>a</sup>	6.7 <sup>a</sup>	9.0 <sup>a</sup>	0.9	9.0
Reptiles and Amphibians	4.0	5.0	4.0	0.9	5.3

<sup>a</sup>Includes 1.0 habitat evaluation point for the value of cottonwoods as bald eagle roosts.



Table 3. Wildlife habitat values for cottonwood-willow habitat.

Faunal Group	Segment			Interspersion Value	Average
	I	II	III		
Big Game	No Site	8.7	8.0	1.0	9.4
Upland Game Mammals		5.0	6.5	1.0	6.8
Furbearers		6.7	6.0	1.0	7.4
Small Mammals		4.0	7.0	1.0	6.5
Upland Game Birds		8.0	7.5	1.0	8.8
Waterfowl		2.0	NA	1.0	3.0
Other Water and Marsh Birds		5.0	NA	1.0	6.0
Terrestrial Birds		5.0	7.5	1.0	7.3
Reptiles and Amphibians		8.0	5.0	1.0	7.5

Table 4. Wildlife habitat values for elm-oak habitat.

Faunal Group	Segment			Interspersion Value	Average
	I	II	III		
Big Game	7.0	7.0	8.0	0.9	8.2
Upland Game Mammals	4.0	7.7	7.0	0.9	7.1
Furbearers	5.0	7.3	7.0	0.9	7.0
Small Mammals	5.5	2.7	6.0	0.9	5.6
Upland Game Birds	6.0	6.0	7.0	0.9	7.1
Waterfowl	NA	NA	NA		NA
Other Water and Marsh Birds	NA	NA	NA		NA
Terrestrial Birds	4.0 <sup>a</sup>	6.2	4.0	0.9	5.6
Reptiles and Amphibians	5.0	2.7	5.0	0.9	5.1

<sup>a</sup>Includes 1.0 habitat evaluation point for the value of eastern red cedar as bald eagle roosts.

Table 5. Wildlife habitat values for sand dune habitat.

Faunal Group	Segment			Interspersion Value	Average
	I	II	III		
Big Game	5.0	4.0	5.0	0.9	5.6
Upland Game Mammals	3.0	3.0	4.0	0.9	4.2
Furbearers	6.0	2.0	3.0	0.9	4.6
Small Mammals	3.5	3.5	4.7	0.9	4.8
Upland Game Birds	3.0	3.0	5.0	0.9	4.6
Waterfowl	NA	NA	NA		NA
Other Water and Marsh Birds	NA	NA	NA		NA
Terrestrial Birds	8.0 <sup>a</sup>	3.0 <sup>a</sup>	3.0 <sup>a</sup>	0.9	5.6
Reptiles and Amphibians	7.0	4.0	6.0	0.9	6.6

<sup>a</sup>Includes 1.0 habitat evaluation point for the value of cottonwoods as bald eagle roosts.